Operator's Manual
Vitesse™ Diode-Pumped,
Modelocked Ti:Sapphire Laser

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Technical Support

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Preface

This manual contains user information for the Vitesse™ Diode-Pumped, Modelocked Ti:Sapphire Laser.

Read this manual carefully before operating the laser for the first time. Special attention should be given to the material in Section One, Laser Safety, that describes the safety features built into the laser.

Use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

Use of the system in a manner other than that described herein may impair the protection provided by the system.

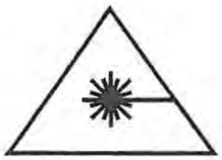
U.S. Export Control Laws Compliance

It is the policy of Coherent to comply strictly with U.S. export control laws.

Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

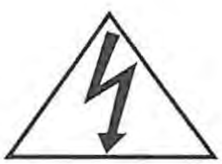
The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification should be obtained from Coherent or an appropriate U.S. Government agency.

Symbols Used in This Manual and on the Laser System



This symbol is intended to alert the operator to the danger of exposure to hazardous visible laser radiation.

This symbol is intended to emphasize the presence of important operating instructions.

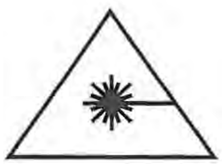


This symbol is intended to alert the operator to the presence of dangerous voltage within the product's enclosure that may be of sufficient magnitude to constitute a risk of electric shock and to indicate possible risk of equipment damage.

SECTION ONE: LASER SAFETY

Optical Safety

Laser light, because of its special properties, poses safety hazards not associated with light from conventional sources. The safe use of lasers requires that all laser users, and everyone near the laser system, are aware of the dangers involved. The safe use of the laser depends upon the user being familiar with the instrument and the properties of coherent, intense beams of light.



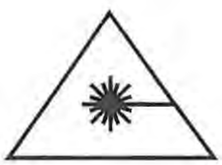
Direct eye contact with the output beam from the laser will cause serious damage and possible blindness.

The greatest concern when using a laser is eye safety. In addition to the main beam, there are often many smaller beams present at various angles near the laser system. These beams are formed by specular reflections of the main beam at polished surfaces such as lenses or beamsplitters. While weaker than the main beam, such beams may still be sufficiently intense to cause eye damage.

Laser beams are powerful enough to burn skin, clothing or paint. They can ignite volatile substances such as alcohol, gasoline, ether and other solvents, and can damage light-sensitive elements in video cameras, photomultipliers and photodiodes. The laser beam can ignite substances in its path, even at some distance. The beam may also cause damage if contacted indirectly from reflective surfaces. For these reasons, and others, the user is advised to follow the precautions below.

1. Observe all safety precautions in the preinstallation and operator's manual.
2. Extreme caution should be exercised when using solvents in the area of the laser.
3. Limit access to the laser to qualified users who are familiar with laser safety practices and who are aware of the dangers involved.
4. Never look directly into the laser light source or at scattered laser light from any reflective surface. Never sight down the beam into the source.
5. Maintain experimental setups at low heights to prevent inadvertent beam-eye encounter at eye level.

6. As a precaution against accidental exposure to the output beam or its reflection, those using the system should wear laser safety glasses as required by the wavelength being generated.
7. Avoid direct exposure to the laser light. The intensity of the beam can easily cause flesh burns or ignite clothing.
8. Use the laser in an enclosed room. Laser light will remain collimated over long distances and therefore presents a potential hazard if not confined.
9. Post warning signs in the area of the laser beam to alert those present.
10. Advise all those using the laser of these precautions. It is good practice to operate the laser in a room with controlled and restricted access.



Laser safety glasses can present a hazard as well as a benefit; while they protect the eye from potentially damaging exposure, they block light at the laser wavelengths, which prevents the operator from seeing the beam. Therefore, use extreme caution even when using safety glasses.

Safety Features and Compliance to Government Requirements

The following features are incorporated into the instrument to conform to several government requirements. The applicable United States Government requirements are contained in 21 CFR, subchapter J, part II administered by the Center for Devices and Radiological Health (CDRH). The European Community requirements for product safety are specified in the Low Voltage Directive (LVD) (published in 73/23/EEC and amended in 93/68/EEC). The Low Voltage Directive requires that lasers comply with the standard EN 61010-1 "Safety Requirements For Electrical Equipment For Measurement, Control and Laboratory Use" and EN 60825-1 "Radiation Safety of Laser Products". Compliance of this laser with the (LVD) requirements is certified by the CE mark.

Laser Classification

The governmental standards and requirements specify that the laser must be classified according to the output power or energy and the laser wavelength. The Vitesse is classified as Class IV based on 21 CFR, subchapter J, part II, section 1040-10 (d). According to the European Community standards, Vitesse lasers are classified as Class 4 based on EN 60825-1, clause 9. In this manual, the classification will be referred to as Class 4.

Protective Housing

The laser head is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class I radiation as specified in the Federal Register, July 31, 1975, Part II, Section 1040.10 (f) (1) and Table 1-A/EN 60825-1, clause 4.2 except for the output beam, which is Class IV.

Laser Radiation Emission Indicators

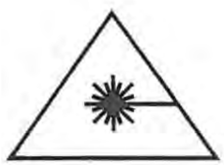
The appropriately labeled lights on both the power supply and the laser head illuminate approximately 30 seconds before laser emission can occur. Amber lights are used so that they will be seen when the proper type of safety glasses are used [CFR 1040.10(f)(5)/EN 60825-1, clause 4.6].

Beam Attenuator

A beam attenuator, or shutter, prevents contact with laser radiation without the need to switch off the laser [CFR 1040.10 (f)(6)/EN 60825-1, clause 4.7].

Operating Controls

The laser controls are positioned so that the operator is not exposed to laser emission while manipulating the controls [CFR 1040.10(f)(7)/EN 60825-1, clause 4.8].



Use of controls or adjustments or performance of procedures other than those specified in the manual may result in hazardous radiation exposure.

Use of the system in a manner other than that described herein may impair the protection provided by the system.

Location of Safety Labels

Refer to Figure 1-1 for a description and location of all safety labels. These include warning labels indicating removable or displaceable protective housings, apertures through which laser radiation is emitted and labels of certification and identification [CFR 1040.10(g), CFR 1040.2, and CFR 1010.3/ EN 60825-1, Clause 5]].

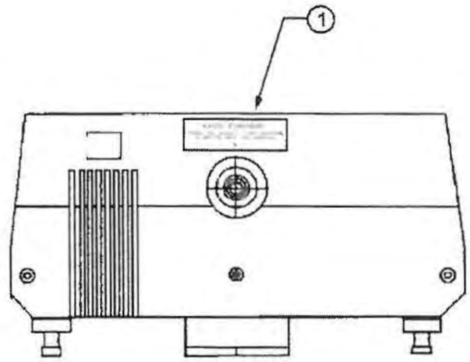
Electromagnetic Compatibility

The European requirements for Electromagnetic Compliance (EMC) are specified in the EMC Directive (published in 89/336/EEC).

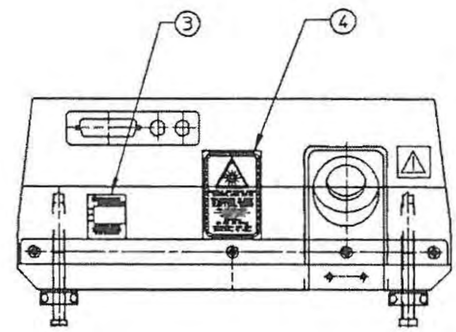
Conformance (EMC) is achieved through compliance with the harmonized standards EN55011 (1991) for emission and ENC50082-1 (1992) for immunity.

The laser meets the emission requirements for Class B, group 1 as specified in EN55011 (1991).

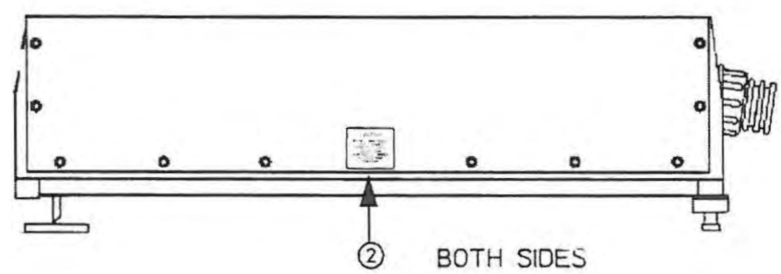
Compliance of this laser with the (EMC) requirements is certified by the CE mark.



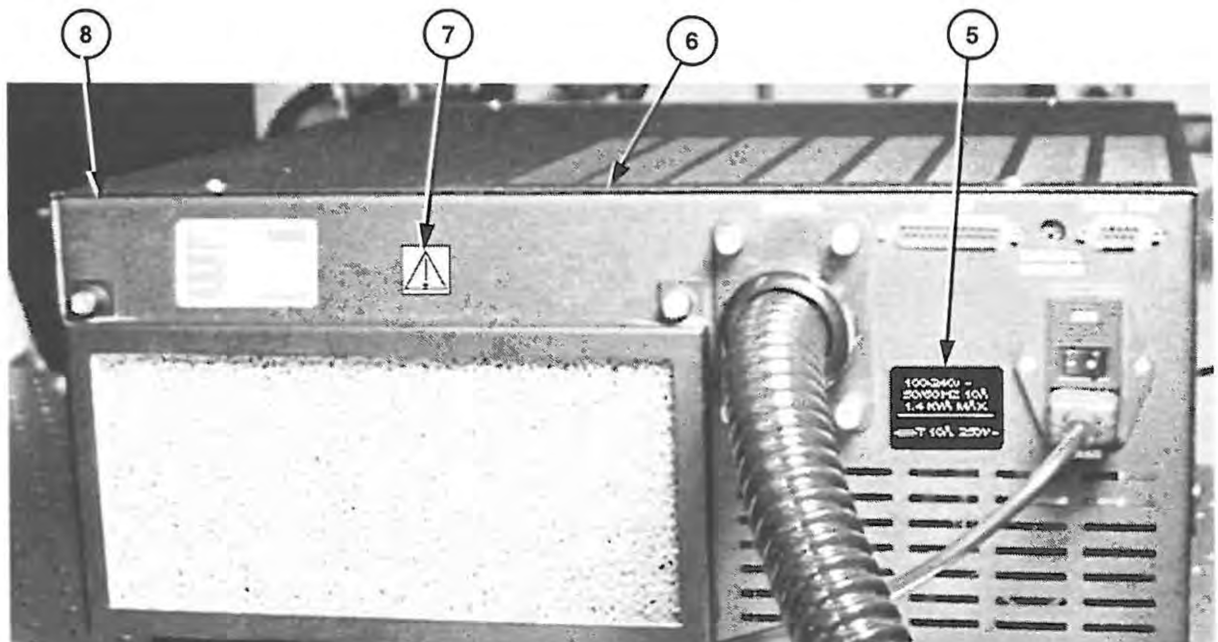
LASER HEAD - FRONT VIEW



LASER HEAD - REAR VIEW

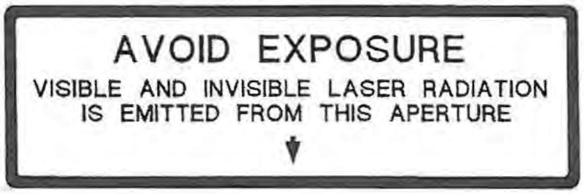


LASER HEAD - SIDE VIEW



POWER SUPPLY

Figure 1-1. Safety Features and Labels (Sheet 1 of 3)



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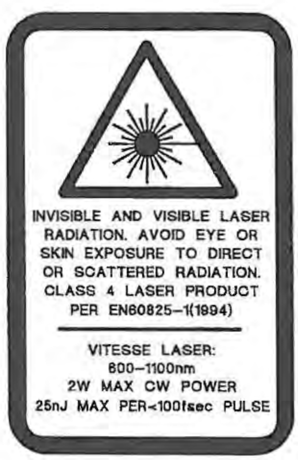

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Figure 1-1. Safety Features and Labels (Sheet 2 of 3)

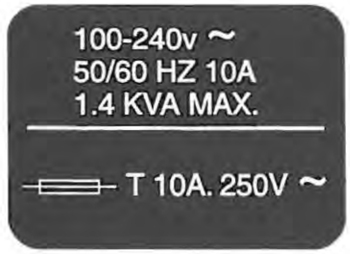

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Figure 1-1. Safety Features and Labels (Sheet 3 of 3)

SECTION TWO: DESCRIPTION AND SPECIFICATIONS

System Description

The Vitesse laser is a compact Verdi-pumped ultrafast laser that produces modelocked, sub-100 femtosecond pulses at an 80 MHz repetition rate with an output power greater than 200 mW average power at 800 nm.

The Vitesse laser (Figure 2-1) consists of the laser head and power supply connected by an umbilical. The umbilical contains fiber optic cables to transmit light from the diode bar in the power supply to the laser head and also houses electrical cables that provide control and monitoring signals between the laser head and power supply.

Vitesse Laser Head

The Vitesse laser head includes (1) a sealed optical cavity (Figure 2-2) with a 2 or 5 Watt, 532 nm Verdi laser head as the pump laser, (2) a PowerTrack mirror, and (3) the Verdi Pumped Ultra-Fast [VPUF] laser head. The laser head also contains beam steering mirrors allowing exact exit beam positioning that is achieved with each Vitesse Laser System.

Figure 2-1. Vitesse Laser System

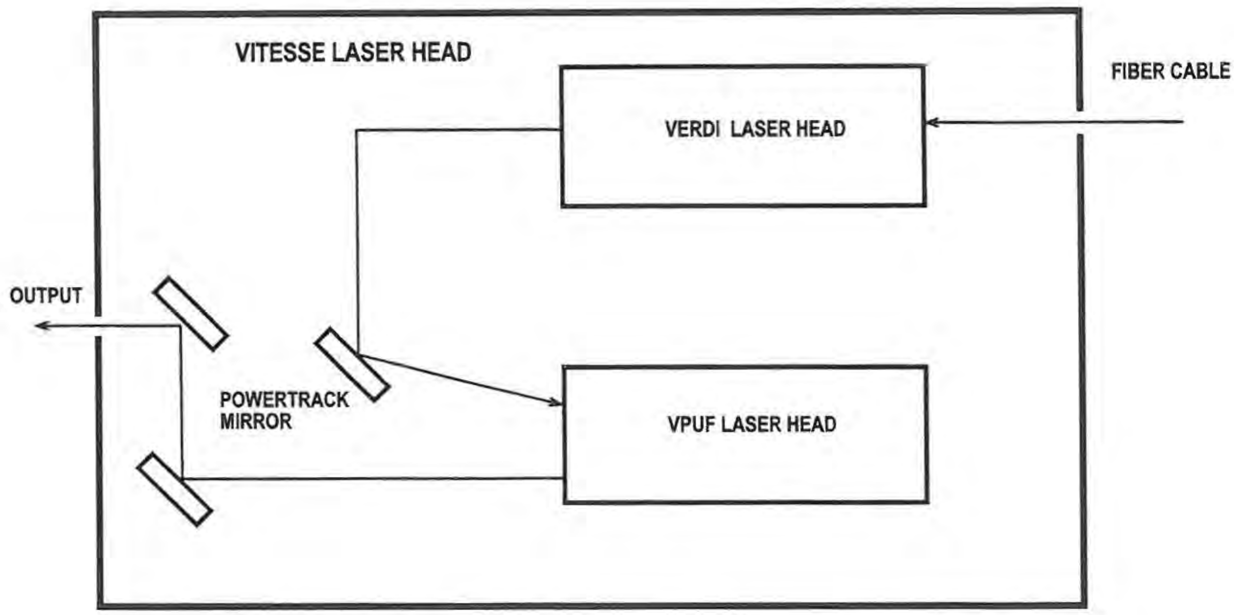


Figure 2-2. Vitesse Laser Head

Verdi Laser Head

The major Verdi optical elements, Figure 2-3, in the sealed pump laser head include Nd-doped Yttrium Vanadate as the gain medium, LBO (Lithium Triborate, LiB_3O_5) as the doubling crystal, an etalon as the single-frequency optic, an optical diode, astigmatic compensator, two pump mirrors, and two end mirrors. All optical components are mounted on Invar for strength and stability.

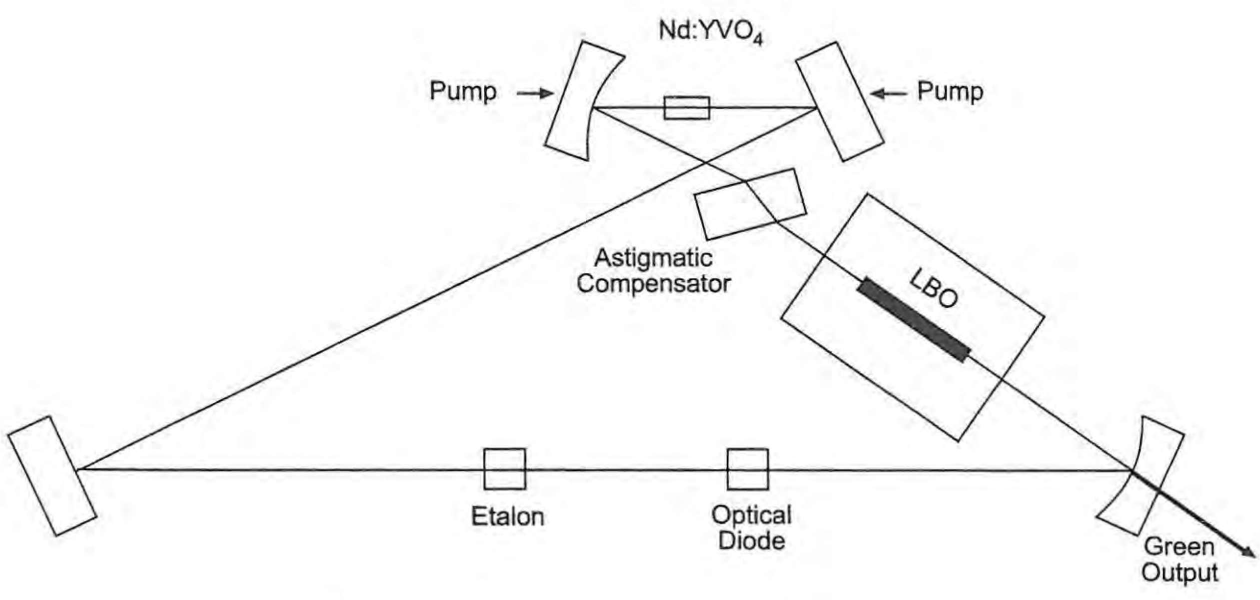


Figure 2-3. Pump (Verdi) Laser Head Optical Schematic

PowerTrack

The PowerTrack function uses a Piezo driven mirror to actively maintain optimum pump beam alignment into the VPUF cavity serving to minimize fluctuations in the Ultrafast output power.

VPUF Laser Head

The VPUF (Figure 2-4) is an ultrafast laser that uses Ti:Sapphire as the gain medium. The proprietary Negative Dispersion Mirrors (NDM) provide the total negative dispersion compensation that is required to produce sub-100 femptosecond pulses. Modelocking is obtained using the Kerr-Lens Modelocking (KLM) technique with an automatic starter triggering the initiation of modelocking. The laser cavity is built on an invar plate for both mechanical strength and stability and is sealed to reduce environmental contamination.

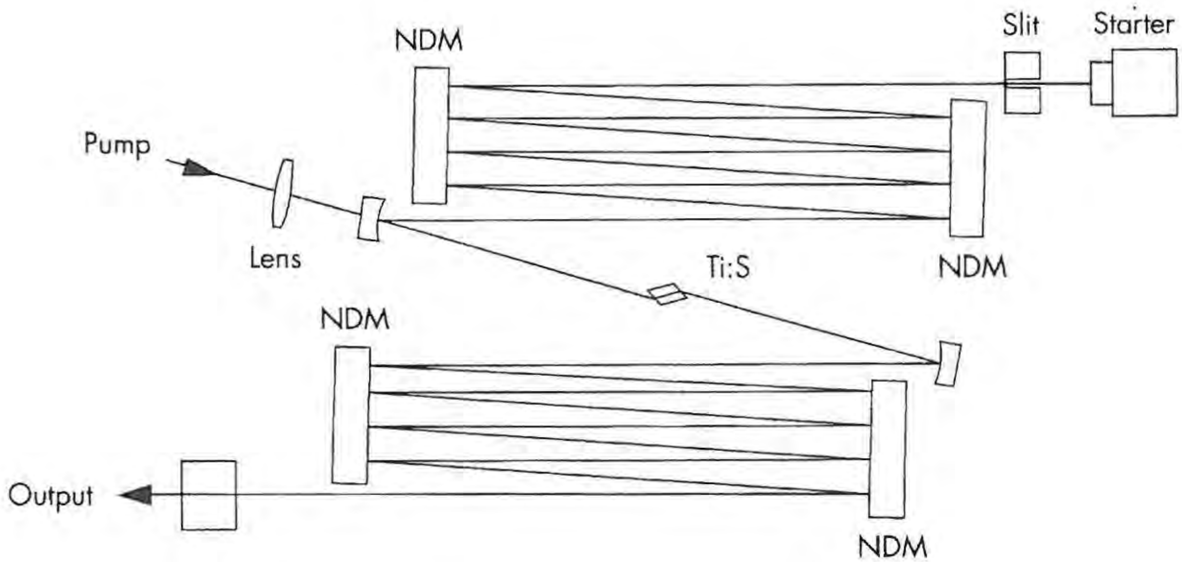


Figure 2-4. VPUF Laser Head Optical Schematic

Power Supply

The main functions of the power supply are to supply dc power for the laser diode system that pumps the gain medium in the Verdi laser head, control six servo loops, provide cooling for the laser diode assemblies, control and monitoring, data storage, and a user interface.

Servo Loops

The CPU controlled servo loops are briefly described below. Additional information is located in Section Seven, Principles of Operation.

- Vitesse light loop – A photodiode in the VPUF head monitors the laser output via the CPU. The CPU controls the output power from the Vitesse based on this photodiode and in conjunction with the requested power from the power supply front panel.
- Verdi light loop - The Verdi light loop functions in a similar manner with the photodiode location in the Verdi head
- LBO temperature – The LBO doubling crystal is held near 150°C by a resistive heater. To prevent rapid change of temperature that may cause LBO crystal damage during warm-up, the CPU regulates a slow ramp-up to operating temperature. This typically lasts between 30 to 45 minutes. In case of loss of AC power due to a power failure or inadvertantly turning off the rear panel power switch, the laser is equipped with a battery powered, microprocessor controlled, cool down feature. This feature gradually lowers the LBO temperature to room temperature.
- Diode heat sink temperature – Diode heat sink temperature is held constant by TECs. Excess heat is dissipated by forced air cooling through heat sinks. The diode heat sinks are located within the power supply.
- Vanadate and etalon temperature – These optical components are maintained at a preset level by TECs.
- PowerTrack - Refer to the paragraph titled, PowerTrack.

Laser Diode Assembly

Depending on the particular model of Vitesse Laser, one or two laser diode assemblies (FAP-I™) are located in the power supply. Each assembly is controlled and monitored by the CPU. The assembly contains a FAP-B™ (fiber array package) which houses a diode bar and a TEC.

Specifications

Specifications for the Vitesse laser are listed in Table 2-1.

The temperature of the Vanadate and etalon are controlled by TECs (thermo-electric coolers) which are capable of heating or cooling the optical element. The temperature of the LBO is controlled by a resistive heater. Accumulated heat in the laser head is dissipated by a water-cooled baseplate. Baseplate temperature is monitored by a CPU in the power supply which will shut the system down if the laser head temperature becomes too high.

Table 2-1. Vitesse Specifications

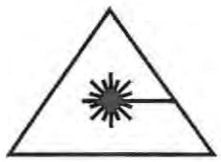
PARAMETER	SPECIFICATION	
	VITESSE 2W	VITESSE 5W
Average Power	>250 mW	>650 mW
Bandwidth[1]	>10 nm	>10 nm
Pulsewidth[2]	<100 fs	<100 fs
Repetion Rate	80±1 MHz	80±1 MHz
Wavelength	800±1 nm	800±1 nm
Power Stability[3]	±1%	±1%
Noise[4]	<0.1% rms	<0.1% rms
Beam Diameter[5] (x)	1.25±0.25 mm	1.45±0.25 mm
Beam Diameter[5] (y)	1.00±0.25 mm	1.20±0.25 mm
Beam Divergence[6] (x)	0.85±0.25 mrad	0.75±0.20 mrad
Beam Divergence[6] (y)	0.95±0.25 mrad	0.90±0.25 mrad
M^2	< 1.1	< 1.1
Polarization	>200:1, horizontal	>200:1, horizontal

All specifications are subject to change without notice.

[1] Full width at half maximum.
[2] Based on $sech^2$ deconvolution of 0.65 times autocorrelation width.
[3] Measured over 2 hours after 15 minute warm-up.
[4] Measured from 10 Hz to 10 MHz
[5] $1/e^2$ at exit port.
[6] Full-angle ($1/e^2$).

SECTION THREE: OPERATION

Operation



Wear laser safety glasses to protect against the radiation generated from the laser. It is assumed that the operator has read Section One, Safety, and is familiar with laser safety practices and the dangers involved. Ensure all personnel in the area are wearing laser safety glasses.

The Vitesse is designed to be operated with the head cover in place. Do not open the Vitesse laser head. There are no user serviceable components or adjustments inside. Warranty will be voided if the enclosure is disassembled.

Turn-on

Turn-on (Cold Start)

The cold start procedure should be used when the Vitesse power supply rear panel power switch has been Off for more than 30 minutes (pump laser in the OFF state as described in Table 3-1). In this condition, all servos are off and the pump laser has to stabilize the servos which can take up to 30 minutes. During this time, the laser diodes cannot be turned on. For additional information on the LBO heater ramp-up and stabilization, refer to the paragraph titled, Thermal Management, located in Section Seven, Principles of Operation.

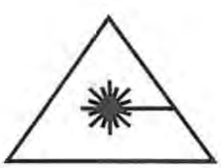
Cold start can also be accomplished when the laser is being externally controlled using a computer. Refer to Tables 4-3 and 4-4 for a list of RS-232 commands and queries.

Ensure the keyswitch is in the STANDBY position prior to performing the following step. Turning the key switch on will result in a fault display until the pump laser LBO reaches the proper temperature.

Table 3-1. Pump Laser Operating States

STATE	SWITCH POSITION	STATUS
OFF	• Power Switch (rear panel): OFF. • All other switches: Any position.	All functions off (except LBO CPU until cool-down is complete).
STANDBY	• Power Switch (rear panel): ON. • Key switch: STANDBY.	Laser diodes off. Vanadate temperature servo on. LBO temperature servo on. Etalon temperature servo on.
ON	• Power Switch (rear panel): ON. • Key switch: ON.	Laser diodes on. Vanadate temperature servo on. LBO temperature servo on. Etalon temperature servo on.

1. Set the Power Switch on the power supply rear panel to On. The AC power and LASER EMISSION indicators will light. If an indicator does not light, refer to Section Five, Maintenance and Service.
2. The power supply display (in the Verdi Status - Servo Status submenu) will indicate that the pump laser servo's are seeking. Refer to Figure 3-3 for the front panel displays and menus.
3. Allow 30 minutes for the pump laser heaters and TE coolers to achieve operating temperature.
4. Access the POWER ADJUSTMENT menu and set the output power to the desired level using the POWER ADJUST knob.



Ensure the laser output is blocked or is directed at an intended target. Ensure all personnel in the area are wearing laser safety glasses.

5. After the heater servo loops are locked at operating temperature as indicated on the power supply display (in the Verdi Status - Servo Status submenu), turn the key switch on the power supply front panel to ON.
6. Laser light will be available from the laser head after a delay of at least 5 seconds.
7. Open the shutter by pressing the SHUTTER OPEN pushbutton on the power supply front panel.

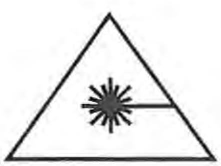
Daily Turn-on (Warm Start)

A warm start can be performed when the Vitesse power supply rear panel power switch has been on for more than 30 minutes (pump laser in standby as described in Table 3-1). The recommended daily operation of the Vitesse is to use this warm start turn-on procedure in conjunction with the turn-off procedure that leaves the rear panel power switch in the ON state.

If the pump laser power supply has been off for more than 30 minutes (AC ON indicator not lit), refer to the procedure titled, "Turn-on (Cold Start)".

Warm start can also be accomplished when the laser is being externally controlled using a computer. Refer to Tables 4-3 and 4-4 for a list of RS-232 commands and queries.

1. The LASER EMISSION indicator should be on. If the indicator is not on, refer to Section Five, Maintenance and Service. Turn the key switch on the power supply front panel to ON.
2. The main menu will appear on the power supply front panel display. Refer to Figure 3-3 for a description of the display menus.



Ensure the laser output is blocked or is directed at an intended target. Ensure all personnel in the area are wearing laser safety glasses.

3. Laser light will be available from the laser head after a delay of at least 5 seconds.
4. Open the shutter by pressing the SHUTTER OPEN pushbutton on the power supply front panel.
5. If necessary, adjust the POWER ADJUST knob (while in the POWER ADJUSTMENT menu) for the desired output power level.

Turn-off

Turn-off (Daily Use)

When the Vitesse is being used on a daily basis, turn-off normally consists of turning the key switch to the STANDBY position. This shuts off the laser diodes and places the pump laser in standby as described in Table 3-1. This method avoids the heater ramp-up cycle described above in the paragraph titled, Turn-on (Cold Start).

Do not turn off the power switch on the power supply rear panel. Refer to the paragraph below titled, Complete Shutdown, if all power is to be removed from the system.

For additional information on LBO heater ramp-up and ramp-down, refer to Section Seven, Principles of Operation.

Turn-off can also be accomplished when the laser is being externally controlled using a computer. Refer to Tables 4-3 and 4-4 for a list of RS-232 commands and queries.

Turn-off (Complete Shut-down)

This procedure will remove all power from the Vitesse and is recommended for performing system maintenance or if no operation is anticipated for a long period of time. Use the cold start procedure to turn on the Vitesse after a complete shut-down.

Complete shut-down can also be accomplished when the laser is being externally controlled using a computer. Refer to Tables 4-3 and 4-4 for a list of RS-232 commands and queries.

1. Turn the key switch power supply front panel to STANDBY.
2. Access and select the LBO SETTINGS submenu. Press the MENU SELECT pushbutton to start the LBO cool-down cycle.

To avoid unnecessary use of the backup battery, do not turn off the power switch on the power supply rear panel while the pump laser is in the cool-down cycle. This takes approximately 45 minutes.

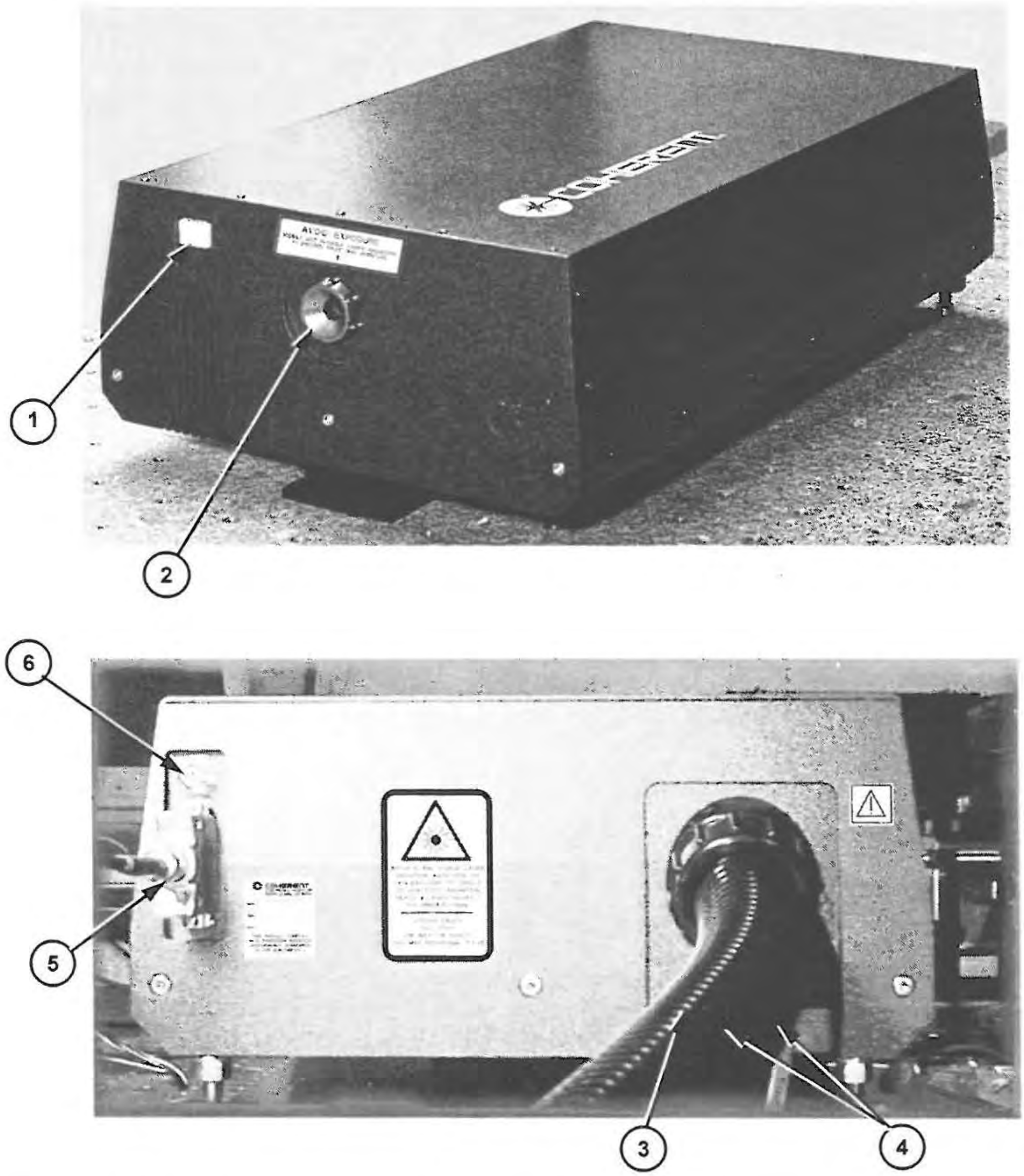
3. When the LBO temperature is below 40°C, turn off the power switch on the power supply rear panel after the cool-down cycle is complete. During the cool-down cycle the LBO temperature can be monitored in the LBO SETTINGS submenu.

Do not turn off the power switch on the rear of the power supply or disconnect AC power from the power supply if a "LBO Battery" fault is active. Refer to Chart 13.

Turning off the power switch (or removing AC power from the power supply) will cause the internal battery to be used to complete the LBO cool-down cycle rather than AC power. This causes unnecessary drain on the battery. For extended battery life use the LBO cool down cycle from the menu. For additional information, refer to the paragraph titled, Thermal Management located in Section Seven, Principles of Operation.

4. The key can be removed to prevent inadvertant turn-on.

Controls, Indicators, and Features

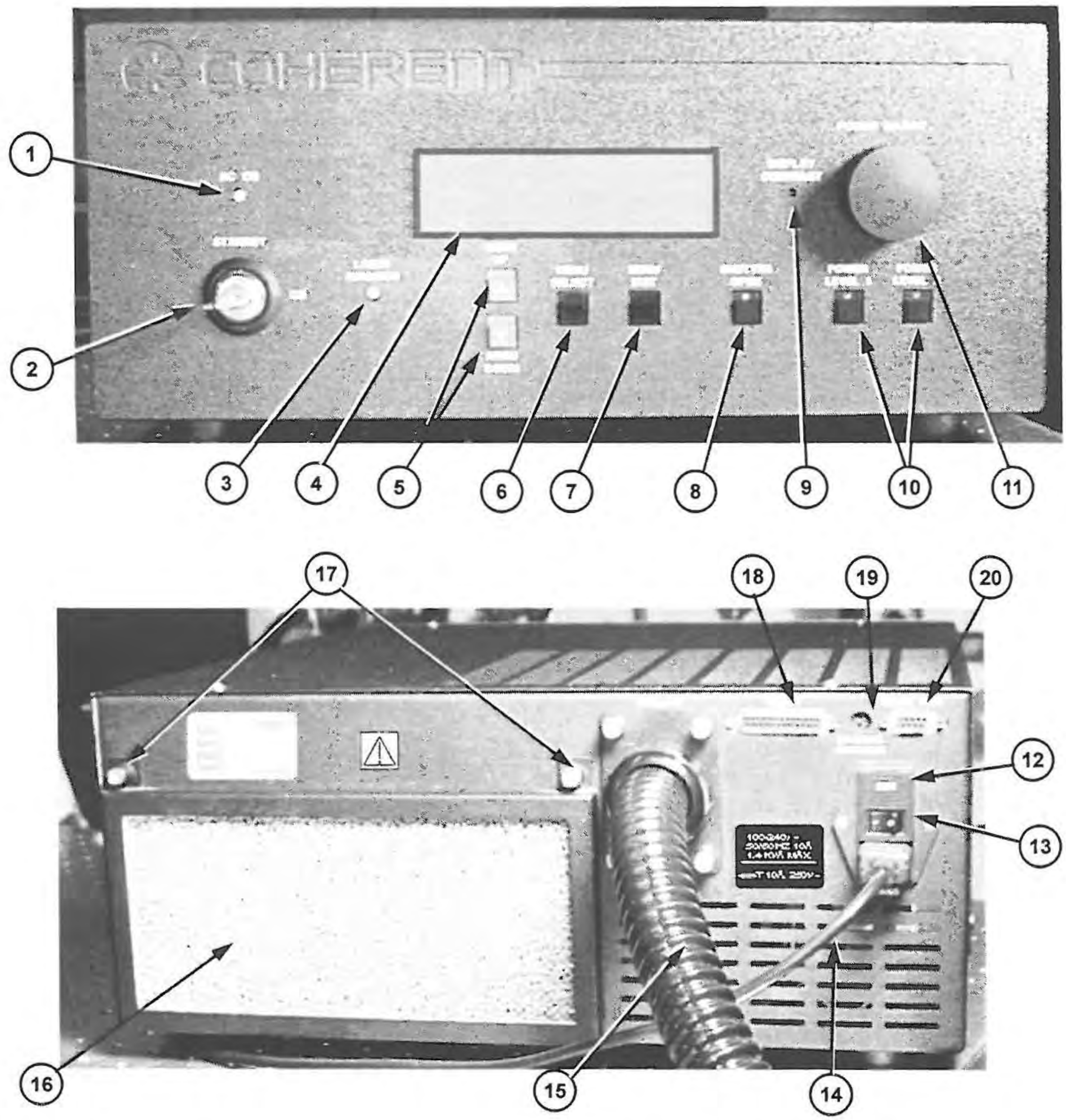


1. Emission indicator
2. Exit window
3. Umbilical
4. Cooling water inlet and outlet lines
5. Slow photo diode (Vitesse power)
6. Fast photo diode (sync out)

Figure 3-1. Laser Head Features

Table 3-2. Laser Head Features

ITEM	CONTROL	FUNCTION
1	Emission indicator	Lights when laser emission is possible.
2	Exit window	800 nm laser light is emitted from this window when the laser is on and the shutter is open.
3	Umbilical	Houses the fiber optic and electrical cables that provides an interface between the laser head and power supply.
4	Cooling water inlet and outlet lines	Connects to facility water or a closed loop chiller. The inlet and outlet connectors are non-directional.
5	Slow photo diode	With SLOW-PD ADAPTOR connected to the test connector (25 pin "D"), the output voltage is representative of the Vitesse output power.
6	Fast photo diode (sync out)	Output for synchronizing external equipment with the Vitesse output pulse. This output can also be used to monitor the output pulse with an oscilloscope.



1. AC ON indicator
2. Key switch
3. LASER EMISSION indicator
4. Display
5. MENU UP/DOWN pushbuttons
6. MENU SELECT pushbutton
7. MENU EXIT pushbutton
8. SHUTTER OPEN pushbutton indicator
9. DISPLAY CONTRAST adjust
10. POWER LEVEL 1/2 pushbutton indicators
11. POWER ADJUST knob
12. Fuses
13. Power ON/OFF switch
14. Power cord
15. Umbilical
16. Air filter
17. Air filter retaining nuts (2)
18. MODEM connector
19. EXTERNAL INTERLOCK connector
20. SERIAL PORT connector

Figure 3-2. Power Supply Controls and Indicators

Table 3-3. Power Supply Controls and Indicators

ITEM	CONTROL	FUNCTION
1	AC ON indicator	Lights when power is applied to the power supply via the power switch on the power supply rear panel.
2	Key switch	The key switch can place the Vitesse either in the STANDBY or ON state. Functionality in these states are summarized in Table 3-1. The key can be removed when in STANDBY position to prevent unauthorized operation. The key cannot be removed when in ON position.
3	LASER EMISSION indicator	Lights when laser emission is possible.
4	Display	Displays pump laser status, operating parameters, and diagnostic data. Refer to Figure 3-3 for a description of the displays.
5	MENU UP/DOWN pushbuttons	Allows scrolling through the menus. Refer to Figure 3-3 for a description of the displays and menus.
6	MENU SELECT push-button	Allows selection of the indicated menu.
7	MENU EXIT push-button	Exits current menu. Can also be used to clear inactive faults as described in the troubleshooting charts in Chapter Four, Maintenance and Service. Pressing MENU EXIT while in the main menu causes the single-frequency mode to recenter as described in Table 4-3, "FLASH" command.
8	SHUTTER OPEN pushbutton indicator	Remotely opens and closes the shutter on the laser head. The pushbutton indicator LED lights when the shutter is disabled.
9	DISPLAY CONTRAST adjust	Allows adjustment of the display by user for best viewing.
10	POWER LEVEL 1/2 pushbutton indicators	Allows selection of 2 preset pump laser output power levels. To preset a power level, press the pushbutton to light the LED. Use the POWER ADJUST knob to set the power, then press the pushbutton again so that the LED is off. The new power value is then stored.
11	POWER ADJUST knob	Allows continuous adjustment of the pump laser output power level from threshold to maximum power.
12	Fuse	250 V, 10 A, time delay fuse provides electrical protection.
13	Power ON/OFF switch	Applies/removes all power from the pump laser. Refer to the shut-down procedures to avoid unnecessary use of the internal battery.
14	Power cord	Connects the power supply to 110 VAC facility power.
15	Umbilical	Houses electrical cables and the fiber optic cables.
16	Air filter	Removes dirt and contamination from the power supply cooling air.
17	Air filter retaining nuts	Secures air filter to power supply.
18	MODEM connector	Reserved for future use.
19	EXTERNAL INTER-LOCK connector	Allows connection of an external interlock. The pump laser will not operate when this connector is open. Refer to the Section Six, Installation, for additional information on the interlock.
20	SERIAL PORT connector	Allows external computer control of the Vitesse. Refer to Section Four for additional information on external computer control including commands, queries, and system requirements.

Menu Displays

Figure 3-3 shows the laser menus. Refer to Table 3-4 for the submenus.

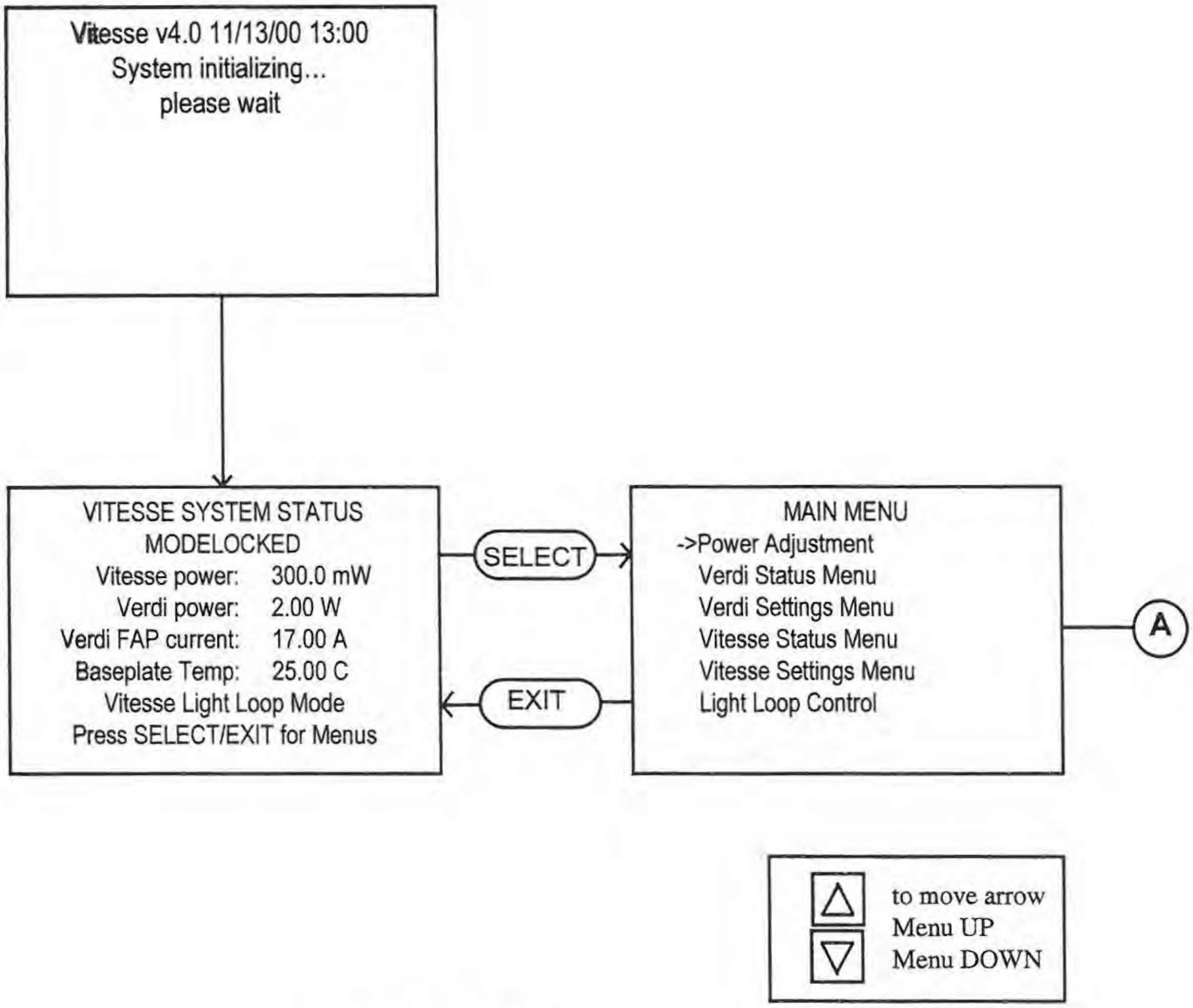
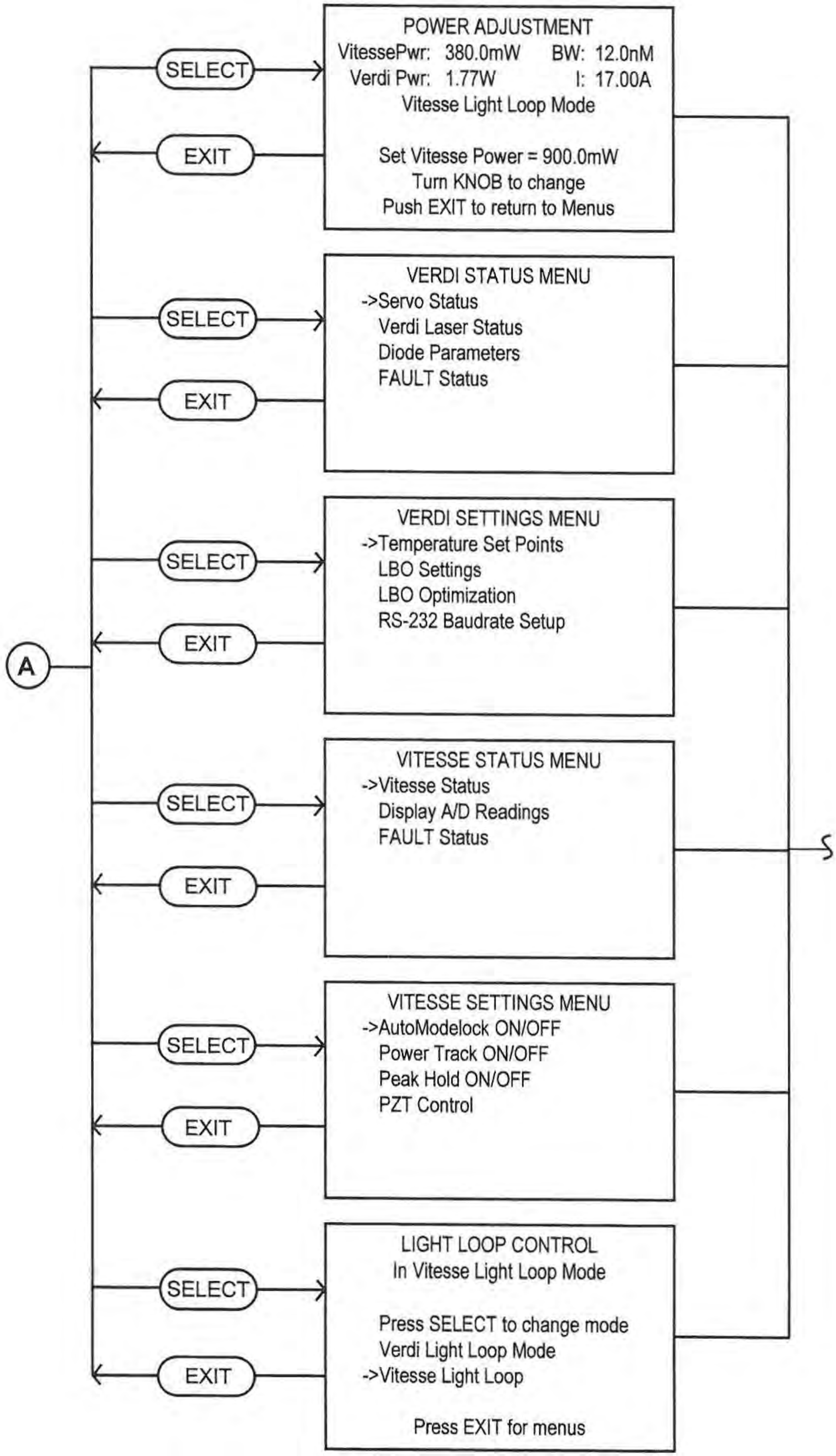


Figure 3-3. Menus



Refer to Table 3-4 for a description of the submenus.

Table 3-4. Submenus (Sheet 1 of 4)

POWER ADJUSTMENT	
VitessePwr: 300.0mW	BW: 12.0nM
Verdi Pwr: 2.00W	I: 17.00A
Vitesse Light Loop Mode	
Set Vitesse Power = 300.0mW	
Turn KNOB to change	
Push EXIT to return to Menus	

The user must access this menu to adjust Vitesse power (when in Vitesse light loop) or Verdi power (when in Verdi light loop).

VERDI STATUS MENUS

SERVO STATUS			
Servo:	State	W/Deg C	Drive
Laser:	open	0.00	0
LBO:	lock	146.6	4784
Vanadate:	lock	35.00	-1776
Etalon:	lock	45.9	428
Diode 1:	seek	16.51	-1431
Diode 2:	lock	15.90	-2180

Displays the Verdi servo status': OPEN, LOCKED, SEEKING, *SEEK, OR FAULT. The value for the laser light loop servo is in Watts and the other values (temperature servos) are °C.

*SEEK indicates the algorithm optimizing the diode temperature is running. This algorithm optimizes the diode temperature such that maximum Vanadate absorption of the IR pump is achieved. Functionally, this lowers the diode pump, and thus operating current, necessary to achieve specified power.

VERDI SETTINGS MENU		
S/W Version	: Verdi 6.05	
System Congf	: 2 Watt System	
Heatsink #1 T	: 23.00 C	
Heatsink #2 T	: 21.70 C	
HEAD Hrs	: 321.98	
DIODE #1 Hrs	: 215.84,	I: 21.50A
DIODE #2 Hrs	: 215.84,	I: 21.00A

Displays Verdi status and system information.

DIODE PARAMETERS	
Diode1 Voltage	: 1.70V
Diode1 Current	: 17.1A
Diode1 Photocell	: 2.49V
Diode2 Voltage	: 1.67V
Diode2 Current	: 17.3A
Diode2 Photocell	: 2.46V

Displays diode voltage, current, and photocell values for the diodes. Recording these values on a periodic basis can be useful in evaluating the health of the system.

FAULT STATUS
System OK:

If faults are active, the fault codes and descriptions will be displayed. Refer to Table 5-1 for a complete list of faults and associated corrective actions.

Table 3-4. Submenus (Sheet 2 of 4)

VERDI SETTING MENUS

```
TEMPERATURE SET POINTS
Set Pt:  150.30     Drive: 6216.9
Read T:  150.31     Status: lock
Set Pwr: 1.90W      Avg I: 16.15A
  ->LBO Temperature
    Vanadate Temperature
    Etalon Temperature
    Diode #1 Temperature
```

Displays the various system temperature set points, actual temperatures and DAC drives required by the servo loops. Temperatures cannot be changed from this menu although the LBO temperature can be optimized using the LBO Temperature Optimization submenu.

```
LBO SETTINGS

T:      150.27     Set: 150.30
Drive:  6224

LBO HEATING
Press SELECT to start COOLING
Press EXIT for NO CHANGE
```

Access this menu to initiate a heating or cooling of the LBO crystal. Displays the state of the LBO servo (heating or cooling).

```
LBO OPTIMIZATION

T: 150.31    Pwr: 1.85    Drv: 6210

OK to OPTIMIZE LBO Temp

Press SELECT to OPTIMIZE Tlbo
Press EXIT to ABORT
```

```
Or
Power TOO LOW!!
Can't optimize at this power!
Press EXIT to ABORT
```

This menu is used to initiate LBO optimization. Refer to the paragraph titled, LBO Temperature Optimization, located in Chapter Five for additional information and procedures regarding LBO Temperature Optimization.

```
RS-232 BAUDRATE SETUP

RS-232 Protocol: 38400, 8, N, 1

use KNOB to adjust rate values

Press SELECT to ACCEPT
Press EXIT to ABORT
```

Allows adjustment of the baudrate for RS-232 communications.

Table 3-4. Submenus (Sheet 3 of 4)

Vitesse Status Menus

Ver : 4.0	Pwr : 1.6mW
Mdlk : NO	BW : 22.8nM
PTrk : OFF	Cw : 420mW
Strt : ON	SetP : 300.5mW
PHld : OFF	QSw : 0.0mW
VLL : ON	LS : 2.29 V
Pzt : Auto	SDac: 2.72 V
Stat : 0	Vrd : 0.01 W

Ver = software version

Mdlk = modelock status (yes or no)

PTrk = power track status (on or off)

Strt = starter status (on or off)

PHld = peak hold (on or off)

VLL = (on or off) Vitesse light loop

Pzt = Pzt control (auto or manual)

Stat = Vitesse light loop state

- 0 = Not operative/Vitesse light loop not on
- 1 = Vitesse light loop "turn-on"
- 2 = Operational and in Vitesse light loop

Pwr = power output

BW = bandwidth

Cw = CW breakthrough point (upper operation range)

SetP = set power

QSw = Q-Switch DAC power level (lower operation range)

LS = loop snoop voltage, normally between 2.1 V to 2.9 V

SDac = voltage used with Vitesse light loop (approx. 2.72 V)

Vrd = Verdi power output

DISPLAY A/D READING	
slow photodiode :	2.02V
PZT X Rd :	2.40 V
PZT Y Rd :	2.42 V
Vitesse loop snoop :	2.00 V
Therm V :	2.99 V
Green Photocell :	3.42 V
Press EXIT to return to Menus	

Displays system devices voltages. Slow photodiode voltage should be approximately 2.5 V at full power. PZT voltages should be between 1 to 4 Volts when PowerTrack is on. Vitesse loop snoop voltage should normally be between 2.1 V to 2.9 V. Therm V voltage (voltage on the Ti:Sapphire crystal) should be approximately 3 V. Green photocell (voltage on the 532 nm photocell) should be about 2.1 Volts.

FAULT STATUS
System OK:

If faults are active, the fault codes and descriptions will be displayed. Refer to Table 5-1 for a complete list of faults and associated corrective actions.

Table 3-4. Submenus (Sheet 4 of 4)

Vitesse Settings Menus

AUTOMODELOCK ON/OFF Automodelock setting : OFF Press SELECT to toggle Setting Press EXIT to return to Menus	Allows the auto modelock function to be turned on or off. The auto modelock is implemented by the starter. Refer to Chapter Seven, Principles of Operation, for additional information.
POWER TRACK ON/OFF Power Track setting : OFF Power Track status : OFF Press SELECT to toggle Setting Press EXIT to return to Menus	Allows the PowerTrack function to be turned on or off. Refer to Chapter Seven, Principles of Operation, for additional information on the power track function.
PEAK HOLD ON/OFF Peak Hold setting : OFF Press SELECT to toggle Setting Press EXIT to return to Menus	Allows the peak hold function to be turned on or off.
PZT CONTROL PZT X: 2.30V VitPwr: 380.0mW PZT Y: 2.30V MODELOCKED Press SELECT to toggle ->PZT mode = AUTO Set PZT X Voltage = *Auto* Set PZT Y Voltage = *Auto* Set AutoModeLock = OFF	Allows the PZT control to be turned to auto or manual. The PZTs implement the PowerTrack function. Refer to Chapter Seven, Principles of Operation, for additional information on PowerTrack.

Fault Handling

In case of a fault, the CPU closes the laser shutter and sets the laser diode current to zero. The display reads for example:

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      FAULT CONDITION!
      ERROR CODE #16
 Diode 1 Over Current Fault
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

    Push EXIT to continue
```

After exiting the fault display, the laser will indicate on the first display line whether the fault is still active. If the fault condition no longer exists, exiting the fault display clears the fault and laser operation returns to the state it was in before the fault occurred except for the shutter which remains closed. If the fault condition still exists, the main menu will display "FAULT ACTIVE" on the first line. Active faults can be seen by selecting the Fault Status Menu.

Some fault messages are for information only and will not set the current to zero. Refer to Table 5-1 for a complete list of fault messages.

SECTION FOUR: EXTERNAL COMPUTER CONTROL

How to Interface to The Vitesse

This chapter provides details on how to interface a Vitesse laser to a remote computer through the RS-232 connector on the rear of the power supply.

The RS-232 interface is based on a set of laser control instructions, consisting of commands that affect laser operation, and queries that request the laser to return status information to the host. The instruction set is sufficient to support user-written programs that emulate the functions of the Vitesse front panel.

RS-232 Command Language

Instruction Syntax for RS-232 Communication

Communication with the Vitesse is by two types of instructions: commands which set the values of laser operating parameters, and queries which request the laser to return the value of an operating parameter.

Any instruction to the laser consists of a command or query written as a string of ASCII characters and terminated by a carriage return and linefeed (<CR><LF>) or a semicolon (;).

For example:

LASER=1<CR><LF>	Switches the Vitesse from STANDBY to ON.
?LIGHT;	Requests the laser to return the measured laser output power.

The laser will always respond to an instruction by returning a message terminated by a carriage return and linefeed. Table 4-1 lists the possible responses from the laser.

For proper handshaking, communication programs should wait until the <CR><LF> has been returned from the laser before sending the next instruction.

Table 4-1. Response from Laser after Receiving Instruction

INSTRUCTION SENT TO LASER	RESPONSE FROM LASER			
	ECHO OFF PROMPT OFF	ECHO OFF PROMPT ON	ECHO ON PROMPT OFF	ECHO ON PROMPT ON
Command + <CR><LF>	<CR><LF>	VERDI><CR> <LF>	Command +<CR><LF>	VERDI> Command +<CR><LF>
Query + <CR><LF>	Data + <CR><LF>	VERDI> Data +<CR><LF>	Query + Data +<CR><LF>	VERDI> Query +Data +<CR><LF>
Command+ <CR><LF> (Illegal operand)	RANGE ERROR: +Command +<CR><LF>	VERDI> RANGE ERROR: +Command +<CR><LF>	Command + RANGE ERROR: +Command +<CR><LF>	VERDI> Command + RANGE ERROR: +Command +<CR><LF>
Command <CR><LF> (Illegal instruction)	Command Error: +Command +<CR><LF>	VERDI> Command Error: +Command +<CR><LF>	Command + Command Error: +Command +<CR><LF>	VERDI> Command + Command Error: +Command +<CR><LF>
Query<CR><LF> (Illegal instruction)	Query Error: +Query +<CR><LF>	VERDI> Query Error: +Query +<CR><LF>	Query +Query Error: +Query +<CR><LF>	VERDI>Query +Query Error: +Query +<CR><LF>

1 Multiple items will be separated by the **&** character. For example, a list of system faults will be returned as **3&5&6**.

ECHO Mode

The Vitesse provides an echo mode in which each character transmitted to the laser is echoed to the host. This feature can be turned on or off using the ECHO command (see below).

PROMPT Mode

The Vitesse provides an prompt mode for terminal operation in which the laser returns "VITESSE" after each command. This feature can be turned on or off using the PROMPT command (see below).

?

The single character **?** may be substituted for **PRINT** in all queries. For example:

?LIGHT is equivalent to **PRINT LIGHT**

= or :

The single characters = and : are equivalent delimiters between text and data in all commands. For example:

LASER=0 is equivalent to **LASER:0**

RS-232 Interface Connection

The Vitesse Laser RS-232 port configuration is described in Table 4-2, and typical cable requirements are shown in Figure 4-1. The 9-pin RS-232 port is configured as DCE (data communications equipment) device using only pins 2 (serial data out), 3 (serial data in) and 5 (signal ground). Handshake lines RTS, CTS, DTR and DSR (pins 4, 6, 7 and 8) are not used and have no connections inside the power supply.

RS-232 Port Configuration

Table 4-2. RS-232 Port Description

CONFIGURATION	DCE, NO HANDSHAKING
Data bits	8
Stop bits	1
Parity	none
Baud rate	User selectable: 1200 2400 4800 9600 19200 38400 (default factory setting) 57600 115200

Setting The Baud Rate

The baud rate of the 9-pin RS-232 port can be adjusted through the front panel (Figure 3-3) or by means of the SERIAL BAUDRATE=NNN command described in Table 4-1 and Table 4-2. After the baud rate is changed, the new setting will be used until it is changed (even if the system power is switched off).

To set the baud rate by the remote computer, send the **SERIAL BAUDRATE=NNN** command to the laser at the currently set baud rate. After sending this baud rate command, host computer communications port must be reinitialized to the new baud rate.

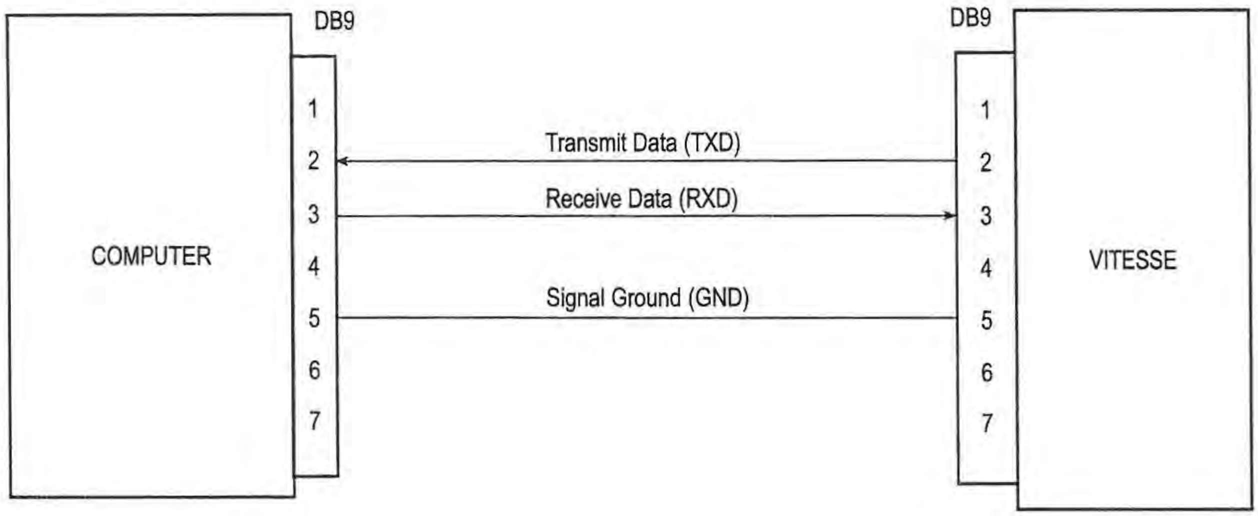


Figure 4-1. RS-232 Pin Configuration

The default factory set baud rate is 38400.

When an RS-232 command is issued to change a setting, the display may not update to reflect the changes taking place in the system. The user should press MENU EXIT and MENU SELECT to update the display.

Instruction Set

Tables 4-3 and 4-4 describe the instructions (long and short forms) for use in RS-232 with the Vitesse.

Table 4-3. RS-232 Commands

COMMANDS	ACTION PERFORMED
AUTOMODELOCK = n AMDLK = n	If n = 0: turns off automodelock (starter). If n = 1: turns on automodelock.
BAUDRATE = nnnnn B=n	Set the RS-232 Serial port baud rate to the specified value. nnnnn = 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200.
ECHO = n E=n	If n = 0: turn OFF echo. Characters transmitted to the laser will not be echoed to the host. If n = 1: turn ON echo. Characters transmitted to the laser will be echoed to the host. A change in echo mode will take effect with the first command sent after the echo command.
FLASH = 1 FL=1	Flash laser output below lasing threshold to allow single-frequency mode to recenter.
LASER = n L=n	If n = 0: put laser in STANDBY (note: key OFF, then ON overrides). If n = 1: reset faults and turn on laser (key must by in ON position). Clears fault screen on power supply and fault history (?FAULT HISTORY) so lasing will resume if no active faults.
LBO HEATER = n LBOH=n	If n = 0: turn off LBO heater (COOL DOWN). If n = 1: turn on LBO heater (HEATING).
LBO OPTIMIZE=n LBOOPT=n	If n=0: no optimization in process. If n=1: begin optimization routine.
LIGHT = nn.nnnn P=nn.nnnn	Set to light regulation at the specified output power.
LOCK FRONT PANEL=n LFP=n	Disables user input from the front panel.
POWER = n P=nn.nnnn	Set to light regulation at the specified output power.
POWER TRACK = n PTRK = n	If n = 0: turn off power track. If n = 1: turn on power track.
PROMPT = n >=n	If n = 0: turn OFF "VERDI>" prompt. If n = 1: turn ON "VERDI>" prompt.
SHUTTER = n S=n	If n = 0: close external shutter. If n = 1: open external shutter.
UF POWER = nnn.nn UF=nnn.nn	Sets UF (Vitesse) power setpoint to the specified value in milliwatts. Only when in Vitesse Light Loop.
VITESSE LIGHT LOOP = n VLL = n	If n = 0: disable Vitesse light loop. Defaults to Verdi Light Loop. If n = 1: enable Vitesse light loop.

Table 4-4. RS-232 Queries

QUERIES	RETURNED INFORMATION
PRINT BANDWIDTH ?BW	Return the Vitesse bandwidth, nn.nn, in nanometers.
PRINT FAULTS ?F	Return a list of number codes of all active faults, separated by an **&**, or return "SYSTEM OK" if no active faults Fault codes: 1=Laser Head Interlock Fault, 2=External Interlock Fault, 3=PS Cover Interlock Fault, 4=LBO Temperature Fault, 5=LBO Not Locked at Set Temp, 6=Vanadate Temp. Fault, 7=Etalon Temp. Fault, 8=Diode 1 Temp. Fault, 9=Diode 2 Temp. Fault, 10=Baseplate Temp. Fault, 11=Heatsink 1 Temp. Fault, 12=Heatsink 2 Temp. Fault, 17=Diode 2 Over Current Fault, 16=Diode 1 Over Current Fault, 19=Diode 1 Under Volt Fault, 18=Over Current Fault, 21=Diode 1 Over Volt Fault, 20=Diode 2 Under Volt Fault, 25=Diode 1 EEPROM Fault, 22=Diode 2 Over Volt Fault, 27=Laser Head EEPROM Fault, 26=Diode 2 EEPROM Fault, 29=PS-Head Mismatch Fault, 28=Power Supply EEPROM Fault, 31=Shutter State Mismatch, 30=LBO Battery Fault, 33=Head PROM Checksum Fault, 32=CPU PROM Checksum Fault, 35=Diode2 PROM Checksum Fault, 34=Diode1 PROM Checksum Fault, 37=Head PROM Range Fault, 36=CPU PROM Range Fault, 39=Diode2 PROM Range Fault, 38=Diode1 PROM Range Fault, 41=Lost Power Track Fault, 40=Lost Modelock Fault, 43=Below Q-Switch Power Fault, 42=Exceeded CW Power Fault, 45=Lost UF Lasing Fault, 44=Ti-Sapph Temp. Fault, 47=PZT Y Fault. 46=PZT X Fault,
PRINT BASEPLATE TEMP ?BT	Return laser head baseplate measured temperature, nn.nn, in °C.
PRINT CURRENT DELTA ?CD	Return the diode current delta calibration, n.n, in amps.
PRINT CURRENT ?C	Return the measured average diode current, nn.n, in amps.
PRINT DIODE1 CURRENT ?D1C	Return laser diode #1 measured current, nn.n, in amps.
PRINT DIODE1 HEATSINK TEMP ?D1HST	Return laser diode #1 heat sink measured temperature, nn.nn, in °C.

Table 4-4. RS-232 Queries (Continued)

QUERIES	RETURNED INFORMATION
PRINT DIODE1 HOURS ?D1H	Return the number of operating hours on laser diode 1.
PRINT DIODE1 SERVO STATUS ?D1SS	Return the status of diode #1 temperature servo: 0 if the servo is OPEN. 1 if the servo is LOCKED. 2 if the servo is SEEKING. 3 if the servo has a FAULT.
PRINT DIODE1 SET TEMP ?D1ST	Return laser diode #1 set temperature, nn.nn, in °C.
PRINT DIODE1 TEMP DRIVE ?D1TD	Return laser diode #1 temperature servo drive setting.
PRINT DIODE1 TEMP ?D1T	Return laser diode #1 measured temperature, nn.nn, in °C.
PRINT DIODE2 CURRENT ?D2C	Return laser diode #2 measured current, nn.n, in amps.
PRINT DIODE2 HEATSINK TEMP ?D2HST	Return laser diode #2 heat sink measured temperature, nn.nn, in °C.
PRINT DIODE2 HOURS ?D2H	Return the number of operating hours on laser diode 2.
PRINT DIODE2 SERVO STATUS ?D2SS	Return the status of diode #2 temperature servo: 0 if the servo is OPEN. 1 if the servo is LOCKED. 2 if the servo is SEEKING. 3 if the servo has a FAULT.
PRINT DIODE2 SET TEMP ?D2ST	Return laser diode #2 set temperature, nn.nn, in °C.
PRINT DIODE2 TEMP DRIVE ?D2TD	Return laser diode #2 temperature servo drive setting
PRINT DIODE2 TEMP ?D2T	Return laser diode #2 measured temperature, nn.nn, in °C.
PRINT ETALON DRIVE ?ED	Return etalon temperature servo drive setting

Table 4-4. RS-232 Queries (Continued)

QUERIES	RETURNED INFORMATION
PRINT ETALON SERVO STATUS ?ESS	Return the status of the etalon temperature servo: 0 if the servo is OPEN. 1 if the servo is LOCKED. 2 if the servo is SEEKING. 3 if the servo has a FAULT.
PRINT ETALON SET TEMP ?EST	Return etalon set temperature, nn.nn, in °C.
PRINT ETALON TEMP ?ET	Return etalon measured temperature, nn.nn, in °C.
PRINT FAULT HISTORY ?FH	Return a list of number codes (see ?F) of all faults that have occurred since the last LASER ON command, separated by an **&**, or return "SYSTEM OK" if no latched faults. The LASER ON command or the EXIT button on the power supply when the fault screen is active will clear the fault history and fault screen.
PRINT HEAD_HOURS ?HH	Return the number of operating hours on the system head.
PRINT KEYSWITCH ?K	Return: 0 if the keyswitch is OFF. 1 if the keyswitch is ON.
PRINT LASER ?L	Return: 0 if the laser is OFF (STANDBY). 1 if the laser is in ON. 2 if the laser is OFF because FAULT occurred (check faults or fault history).
PRINT LBO DRIVE ?LBOD	Return LBO temperature servo drive setting
PRINT LBO HEATER ?LBOH	Return the status of the LBO heater: 0 if the LBO heater is OFF (COOL DOWN). 1 if the LBO heater is ON (HEATING).
PRINT LBO SERVO STATUS ?LBOSS	Return the status of the LBO temperature servo: 0 if the servo is OPEN. 1 if the servo is LOCKED. 2 if the servo is SEEKING. 3 if the servo has a FAULT.
PRINT LBO SET TEMP ?LBOST	Return LBO set temperature, nnn.nn, in °C.
PRINT LBO TEMP ?LBOT	Return LBO measured temperature, nnn.nn, in °C.

Table 4-4. RS-232 Queries (Continued)

QUERIES	RETURNED INFORMATION
PRINT LIGHT REG STATUS ?LRS	Return the status of the light loop servo: 0 if the servo is OPEN (current regulation). 1 if the servo is LOCKED. 2 if the servo is SEEKING. 3 if the servo has a FAULT.
PRINT LIGHT ?P	Return the calibrated output power, nn.nnn, in watts.
PRINT MODE ?M	Returns the laser operating mode: 0 if in current regulation. 1 if in light regulation.
PRINT MODELOCKED ?MDLK	Return: 0 if Vitesse is off (standby). 1 if Vitesse is modelocked. 2 if Vitesse is CW.
PRINT POWER TRACK ?PTRK	Return: 0 if power track is off. 1 if power track is on.
PRINT SET LIGHT ?SP	Return the light regulation set power, nn.nnnn, in watts.
PRINT SHUTTER ?S	Return the status of the external shutter: 0 if the shutter CLOSED. 1 if the shutter OPEN.
PRINT SOFTWARE ?SV	Return the version number of the power supply software.
PRINT UF POWER ?UF	Return: Actual UF (Vitesse) power, nnn.nn, in milliwatts
PRINT VANADATE DRIVE ?VD	Return vanadate temperature servo drive setting
PRINT VANADATE SERVO STATUS ?VSS	Return the status of the vanadate temperature servo: 0 if the servo is OPEN. 1 if the servo is LOCKED. 2 if the servo is SEEKING. 3 if the servo has a FAULT.
PRINT VANADATE SET TEMP ?VST	Return vanadate set temperature, nn.nn, in °C.

Table 4-4. RS-232 Queries (Continued)

QUERIES	RETURNED INFORMATION
PRINT VANADATE TEMP ?VT	Return vanadate measured temperature, nn.nn, in °C.
PRINT VITESSE LIGHT LOOP ?VLL	Return: 0 if Vitesse light loop is off. 1 if Vitesse light loop is on.

SECTION FIVE: MAINTENANCE AND SERVICE

Do not open the Vitesse laser head. There are no user serviceable components or adjustments inside. There are dangerous high voltage and currents and hazardous levels of laser energy inside the laser head. There is no cover interlock to eliminate these dangers upon removal of the laser head cover.

Troubleshooting

Table 5-1 lists possible problems/error messages with a reference to the associated troubleshooting chart located in this section.

Table 5-1. Troubleshooting/Fault Messages

PROBLEM	TROUBLESHOOTING REFERENCE
Pump laser does not start (no laser output)	Chart 1
Pump laser shuts down	Chart 2
Vitesse laser output unstable	Chart 3
AC ON indicator on power supply front panel does not light when power switch on rear panel is ON.	Chart 4
LASER EMISSION indicator on power supply front panel or on the laser head does not light when key switch is in the ON position.	[1]
FAULT MESSAGES:	
Fault Code 1: Head interlock fault	Chart 5
Fault Code 2: External interlock fault	Chart 6
Fault Code 3: Power supply cover interlock fault	Chart 7
Fault Code 4: LBO temperature fault	Chart 8
Fault Code 5: LBO Not Locked at Set Temperature	Chart 12
[1] Contact Coherent or an authorized representative. If the laser system or components are being returned directly to Coherent, an RMA (Return Material Authorization) number is required.	

Table 5-1. Troubleshooting/Fault Messages (Continued)

PROBLEM	TROUBLESHOOTING REFERENCE
Fault Code 6: Vanadate temperature fault	Chart 8
Fault Code 7: Etalon temperature fault	Chart 8
Fault Code 8: Diode 1 temperature fault	Chart 8
Fault Code 9: Diode 2 temperature fault	Chart 8
Fault Code 10: Baseplate temperature fault	Chart 9
Fault Code 11: Diode heat sink 1 temperature fault	Chart 10
Fault Code 12: Diode heat sink 2 temperature fault	Chart 10
Fault Code 16: Diode 1 over current fault	Chart 11
Fault Code 17: Diode 2 over current fault	Chart 11
Fault Code 18: Over current fault	Chart 11
Fault Code 19: Diode 1 under voltage fault	Chart 12
Fault Code 20: Diode 2 under voltage fault	Chart 12
Fault Code 21: Diode 1 over voltage fault	Chart 12
Fault Code 22: Diode 2 over voltage fault	Chart 12
Fault Code 25: Diode 1 EEPROM fault	Chart 12
Fault Code 26: Diode 2 EEPROM fault	Chart 12
Fault Code 27: Laser Head EEPROM fault	Chart 12
Fault Code 28: Power Supply EEPROM fault	Chart 12
Fault Code 29: Power supply-head mismatch fault	Chart 12
Fault Code 30: LBO battery fault	Chart 13
Fault Code 31: Shutter state mismatch	Chart 12
Fault Code 32: CPU PROM Checksum Fault	Chart 12
Fault Code 33: Head PROM Checksum Fault	Chart 12
Fault Code 34: Diode1 PROM Checksum Fault	Chart 12
Fault Code 35: Diode2 PROM Checksum Fault	Chart 12

Table 5-1. Troubleshooting/Fault Messages (Continued)

PROBLEM	**TROUBLESHOOTING REFERENCE**
Fault Code 36: CPU PROM Range Fault	Chart 12
Fault Code 37: Head PROM Range Fault	Chart 12
Fault Code 38: Diode1 PROM Range Fault	Chart 12
Fault Code 39: Diode2 PROM Range Fault	Chart 12
Fault Code 40: Lost Modelock Fault	Chart 12
Fault Code 41: Lost Power Track Fault	Chart 12
Fault Code 42: Exceeded CW Power Fault	Chart 12
Fault Code 43: Below Q-Switch Power Fault	Chart 12
Fault Code 44: Ti-Sapph Temp. Fault	Chart 8
Fault Code 45: Lost UF Lasing Fault	Chart 12
Fault Code 46: PZT X Fault	Chart 14
Fault Code 47: PZT Y Fault	Chart 14

Chart 1. Pump Laser Does Not Start (No Light Output)

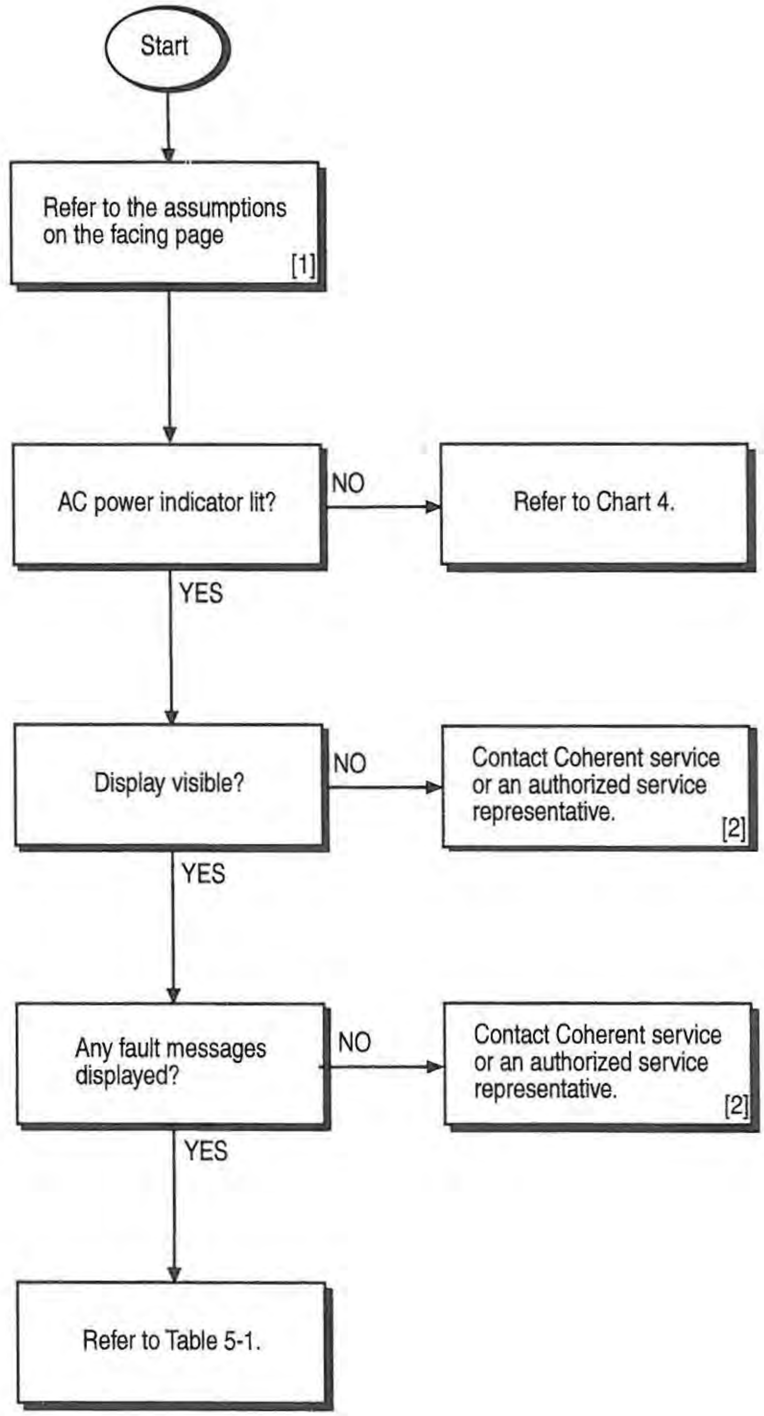


Chart 1. Pump Laser Does Not Start (No Light Output) [Continued]

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[1] ASSUMPTIONS:

- The laser system has been installed in accordance with the installation procedures in Section Six, Installation.
- This procedure is not intended for re-starting a laser after it has shut down due to a fault.
- A closed shutter is not blocking output light.
- The appropriate turn-on procedures are being performed and the laser is not in a warm-up cycle.

[2] If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required.

Chart 2. Pump Laser Shuts Down (No Light Output)

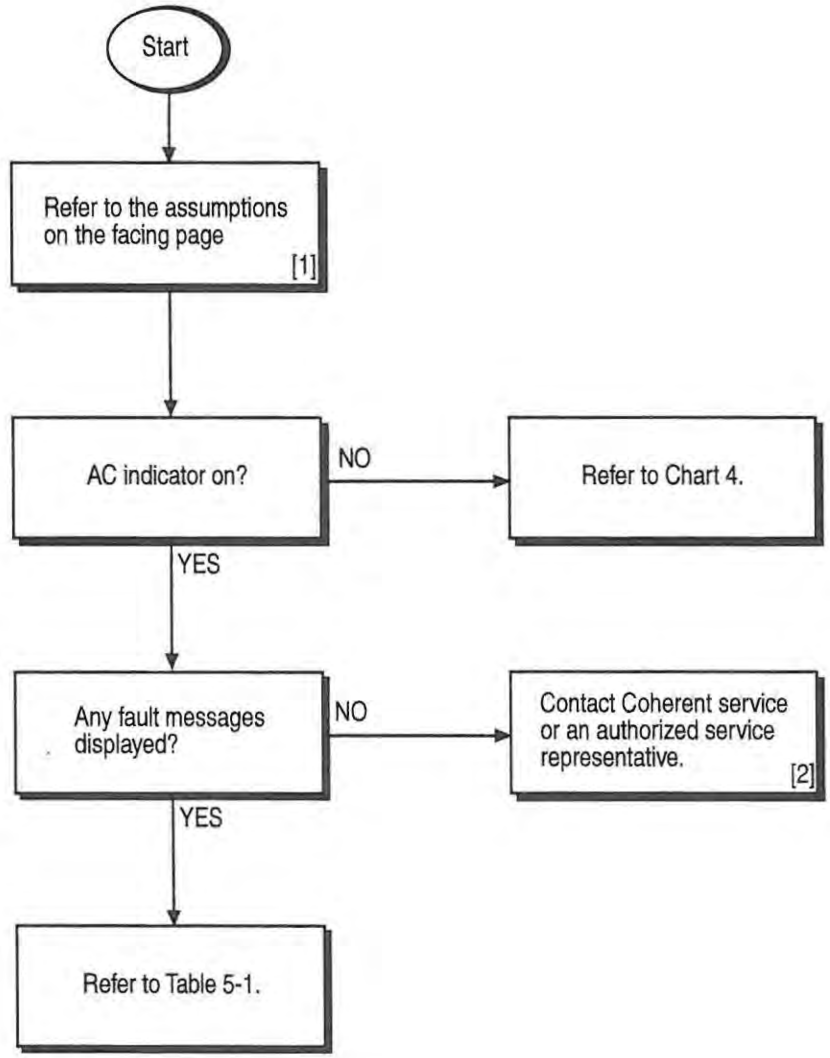


Chart 2. Pump Laser Shuts Down (No Light Output) [Continued]

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[1] ASSUMPTIONS:

- The laser system had been operating immediately prior to shutdown.
- The interlocks are closed as described in Section Six, Installation. The pump laser will not operate with an interlock circuit open.

  If a user interlock is installed, the user interlock can be verified by temporarily replacing it with the interlock supplied with the system.

[2] If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 3. Laser Output Unstable

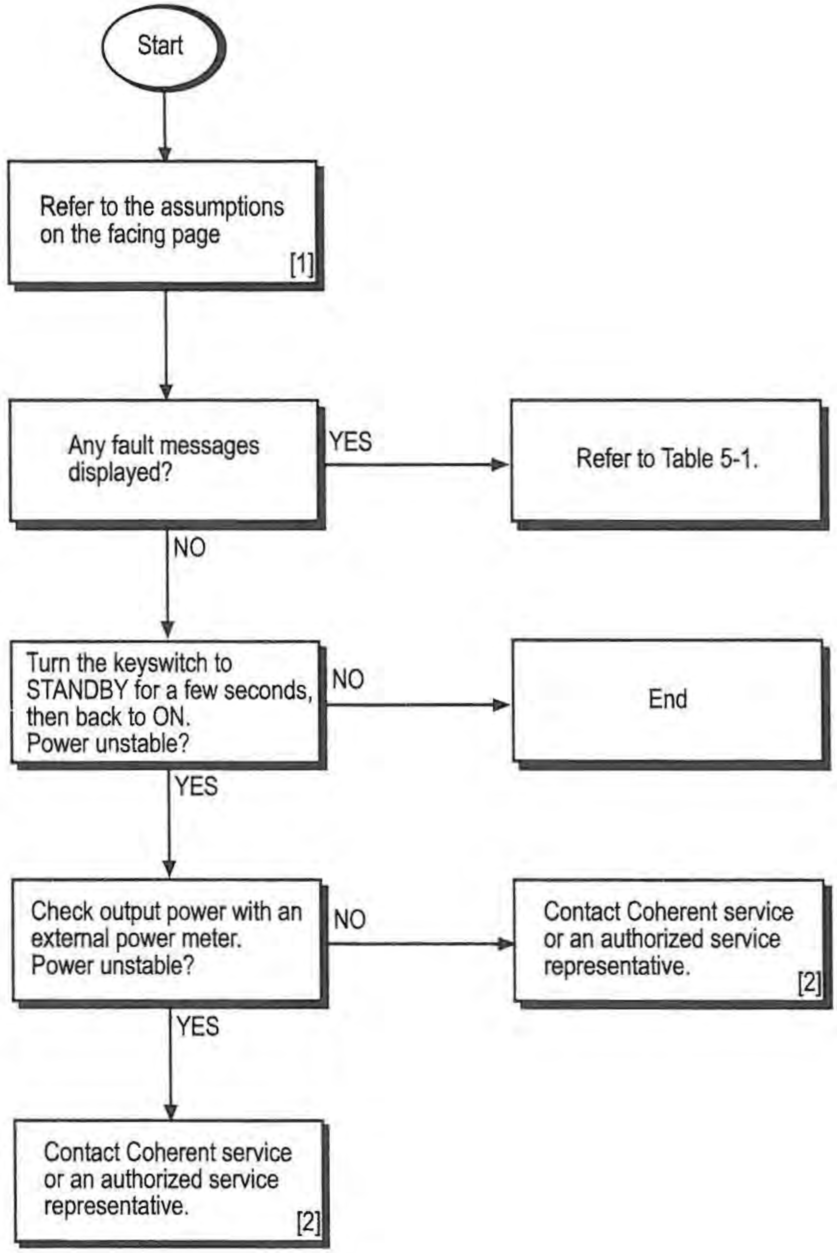


Chart 3. Pump Laser Output Unstable [Continued]

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[1] ASSUMPTIONS:

- The laser system has been installed in accordance with the installation procedures in Section Six, Installation.

[2] If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 4. AC ON Indicator Does Not Light

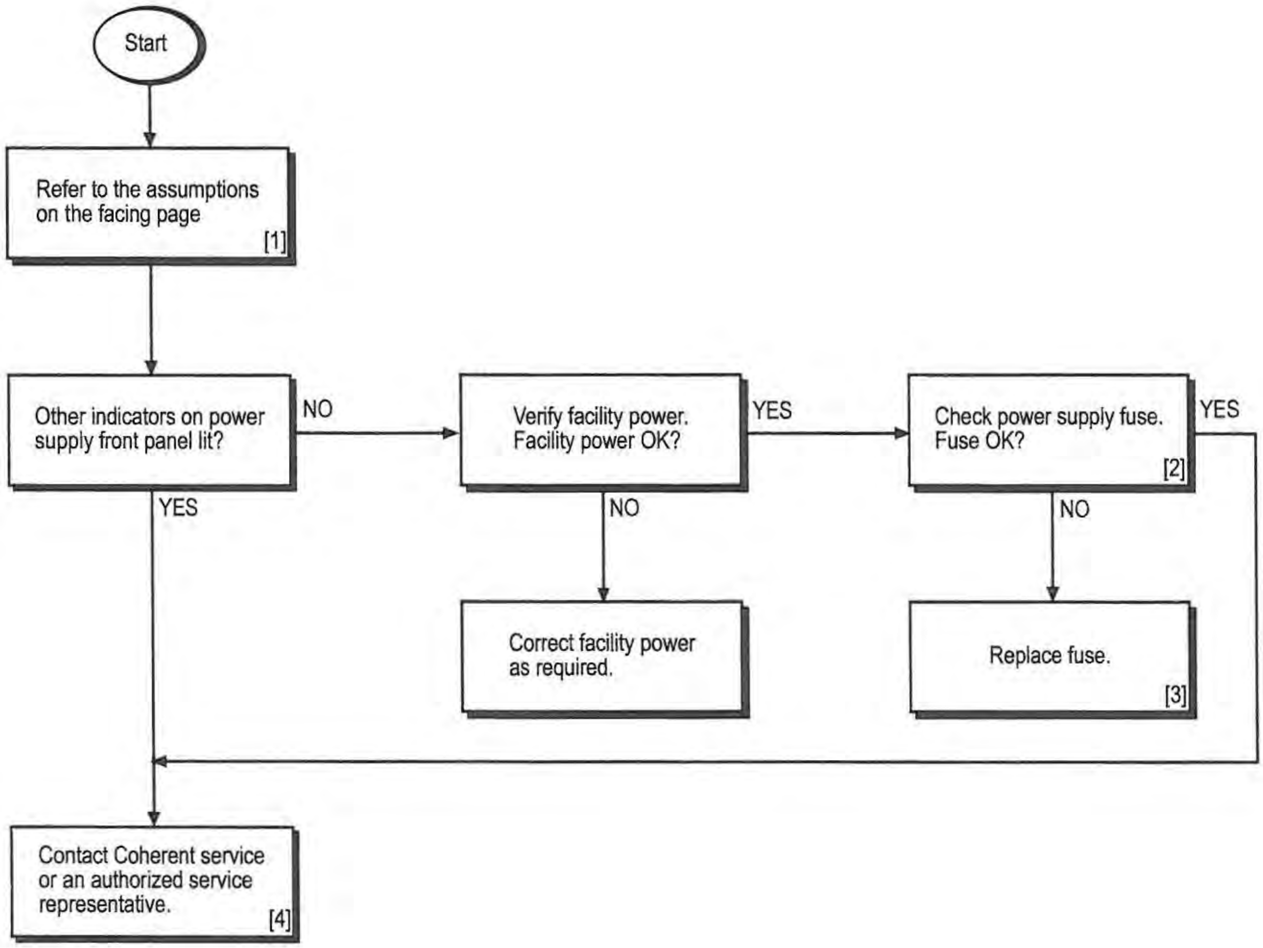


Chart 4. AC ON Indicator Does Not Light [Continued]

The numbered paragraphs below are keyed to, and supplement the flowchart for this chart.

[1] ASSUMPTIONS:

- The laser system has been installed in accordance with the installation procedures in Section Six, Installation.
- The power cord is connected to an active facility power source and the power switch on the power supply rear panel is on.

[2] After performing the Turn-Off (Complete Shut down) procedures located in Section Three, disconnect the laser system from facility power and remove the fuse (Figure 3-2, item 12) using the fuse replacement procedures located in this section. Verify continuity (closed circuit) between the two fuse terminals.

[3] Refer to the fuse replacement procedures located in this section. If the fault persists, contact Coherent or an authorized representative.

[4] If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 5. Head Interlock Fault

[1]	Press MENU EXIT to clear the fault display. If the fault does not clear, a fault message will appear on the main menu and on the fault status menu (Figure 3-3). If the fault clears, open the shutter and resume operation.
[2]	Ensure the umbilical is not strained and that bend radius is 5 inches or greater.
[3]	Turn the power switch on the power supply rear panel to Off for approximately 20 seconds. Then turn the switch back to On.
[4]	If the fault persists, contact Coherent or an authorized representative. If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 6. External Interlock Fault

The laser system will not operate with an open interlock circuit. Ensure the external interlock supplied with the system or an user furnished interlock is installed. Refer to the paragraph titled, External Interlock, located in Section Six, Installation.

[1] Press MENU EXIT to clear the fault display.

If the fault does not clear, a fault message will appear on the main menu and on the fault status menu (Figure 3-3).

If the fault clears, open the shutter and resume operation.

[2] Ensure the connector that is connected to the EXTERNAL INTERLOCK connector on the power supply rear panel is firmly seated.

[3] If a user interlock is installed, turn the key switch to STANDBY and replace the user interlock circuit with the external interlock supplied with the system. If the fault clears, the user interlock circuit is defective.

If the fault does not clear, verify continuity of the interlock connector.

If the fault clears, open the shutter and resume operation.

[4] Turn the power switch on the power supply rear panel to Off for approximately 20 seconds. Then turn the switch back to On.

[5] If the fault persists, contact Coherent or an authorized representative. If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 7. Power Supply Cover Interlock Fault

It is possible that the top cover of the power supply is not secure, turn the key switch to STANDBY and verify the power supply top cover is securely closed with all fasteners.

[1] Press MENU EXIT to clear the fault display.

If the fault does not clear, a fault message indication will appear on the main menu and on the fault status menu (Figure 3-3).

If the fault clears, open the shutter and resume operation.

[2] Turn the power switch on the power supply rear panel to Off for approximately 20 seconds. Then turn the switch back to On.

[3] If the fault persists, contact Coherent or an authorized representative. If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 8. LBO Temperature Fault
Vanadate Temperature Fault
Etalon Temperature Fault
Diode Temperature Fault
Ti-Sapph Temp. Fault

Note: The above faults relate to the pump laser.

[1] Press MENU EXIT to clear the fault display.

If the fault does not clear, a fault message will appear on the main menu and on the fault status menu (Figure 3-3).

If the fault clears, open the shutter and resume operation.

[2] Verify the set point is the same as on the test sheet. If different, contact Coherent or an authorized representative.

[3] Turn the power switch on the power supply rear panel to Off for approximately 20 seconds. Then turn the switch back to On.

[4] If the fault persists, contact Coherent or an authorized representative. If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 9. Baseplate Temperature Fault

[1] ASSUMPTIONS:

- The laser system has been installed in accordance with the installation procedures in Section Six, Installation.

[2] Press MENU EXIT to clear the fault display.

If the fault does not clear, a fault message will appear on the main menu and on the fault status menu (Figure 3-3).

If the fault clears, open the shutter and resume operation.

[3] Ensure that the ambient temperature is not abnormally high and the laser head is not located near a heat generating source.

If a suitable ambient temperature cannot be maintained or if the laser head must be located in a less than optimum location.

[4] Turn the power switch on the power supply rear panel to Off for approximately 20 seconds. Then turn the switch back to On.

[5] If the fault persists (and the ambient temperature and laser head location meet the above requirements), contact Coherent or an authorized representative. If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 10. Diode Heat Sink Temperature Fault (power supply)

[1] Press MENU EXIT to clear the fault display.

If the fault does not clear, a fault message will appear on the main menu and on the fault status menu (Figure 3-3).

If the fault clears, open the shutter and resume operation.

[2] Verify the following:

- The cooling fans are not obstructed,
- The rear, top, and left side of the power supply are not obstructed,
- The air filter is not clogged (do not remove the air filter when the fans are rotating),
- The power supply is not located near a heat source,
- The ambient temperature is not excessively high.

[3] Turn the power switch on the power supply rear panel to OFF for approximately 20 seconds. Then turn the switch back to ON.

[4] If the fault persists (and the ambient temperature and power supply location meet the above requirements), contact Coherent or an authorized representative. If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 11. Over Current Fault
Diode Over Current Fault (pump laser)

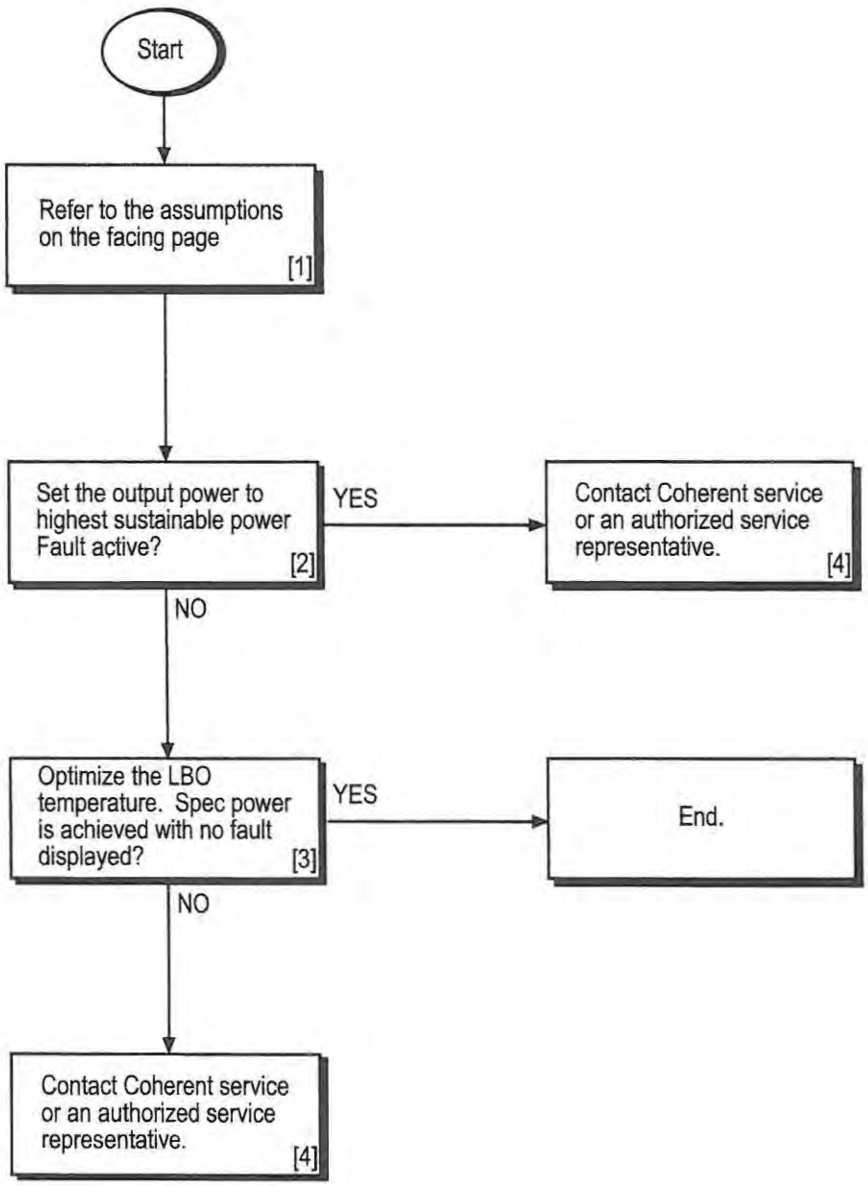


Chart 11. Over Current Fault [Continued]
Diode Over Current Fault

[1] ASSUMPTIONS:

- The laser system has been installed in accordance with the installation procedures in Section Six, Installation.

[2] If the fault is displayed, press EXIT to clear the fault.

[3] Procedures for LBO temperature optimization are located in this chapter.

[4] If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 12. Below Q-Switch Fault
CPU PROM Checksum Fault
CPU PROM Range Fault
Diode Under Voltage Fault
Diode Over Voltage Fault
Diode EEPROM Fault
Diode PROM Range Fault
Diode PROM Checksum Fault
Exceeded CW Power Fault
Head PROM Checksum Fault
Head PROM Range Fault
Laser Head EEPROM Fault
LBO Not Locked at Set Temperature
Lost Modelock Fault
Lost Power Track Fault
Lost UF Lasing Fault
Power Supply EEPROM Fault
Power Supply-Head Mismatch Fault
Shutter State Mismatch

[1] Press MENU EXIT to clear the fault display.

If the fault does not clear, a fault message will appear on the main menu and on the fault status menu (Figure 3-3).

If the fault clears, open the shutter and resume operation.

[2] Turn the power switch on the power supply rear panel to Off for approximately 20 seconds. Then turn the switch back to On.

[3] If the fault persists, contact Coherent or an authorized representative. If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 13. LBO Battery Fault

[1] Press MENU EXIT to clear the fault display.

If the fault does not clear, a fault message will appear on the main menu and on the fault status menu (Figure 3-3).

If the fault clears, open the shutter and resume operation.

If necessary, perform shutdown using the "LBO SETTING" menu. Do not turn off the power supply switch on the rear panel (or remove AC power) when an LBO Battery fault is active.

[2] If the fault persists, contact Coherent or an authorized representative. If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

Chart 14. PZT Fault

[1]	Press MENU EXIT to clear the fault display. If the fault does not clear, a fault message will appear on the main menu and on the fault status menu (Figure 3-3). If the fault clears, open the shutter and resume operation.
[2]	Use the Vitesse Status Menu to verify the PZT is out of range (in range is 0.5 to 4.7V).
[3]	Use the Vitesse Status Menu to ensure the PZT is in the AUTO mode. If not, set the PZT(s) to AUTO. If PZT MANUAL mode is desired, adjust the PZT voltage within range.
[4]	If the fault persists, contact Coherent or an authorized representative. If the laser system must be returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

FAP-I Replacement

Refer to the troubleshooting charts prior to replacing the FAP-I. Contact Coherent technical support or a local service representative to assist in determining the need for FAP-I replacement.

Preliminary Steps and Data

1. With the laser system in "Standby" mode, record the following system parameters:
   a. LBO temperature set point
   b. Vanadate temperature set point
   c. Etalon temperature set point
   d. FAP-I temperature set points
2. Perform the "Turn-off (Complete Shut Down)" procedure located in Section Three of the Operator's Manual. The associated cool-down cycle will take approximately 45 minutes. The front panel display will indicate when the cool-down cycle is complete.

Do not turn off the power switch or disconnect the AC power input until the cool down cycle is complete.

3. When the LBO cool down cycle is complete, turn off the power switch on the power supply rear panel.

   Do not disconnect the power cord from facility power. The power supply chassis must be grounded either by the power cord or a separate ground to avoid ESD.
4. Remove the top cover of the power supply.

The FAP-I can be damaged by electro-static discharge (ESD). To avoid ESD, a personal grounding strap should be used at all times.

FAP-I Handling Precautions

1. The FAP-I can be damaged (electro-static discharge, ESD) by improper handling. To avoid ESD, a personal grounding strap should be used at all times. Follow the instructions that accompany the personal grounding strap.

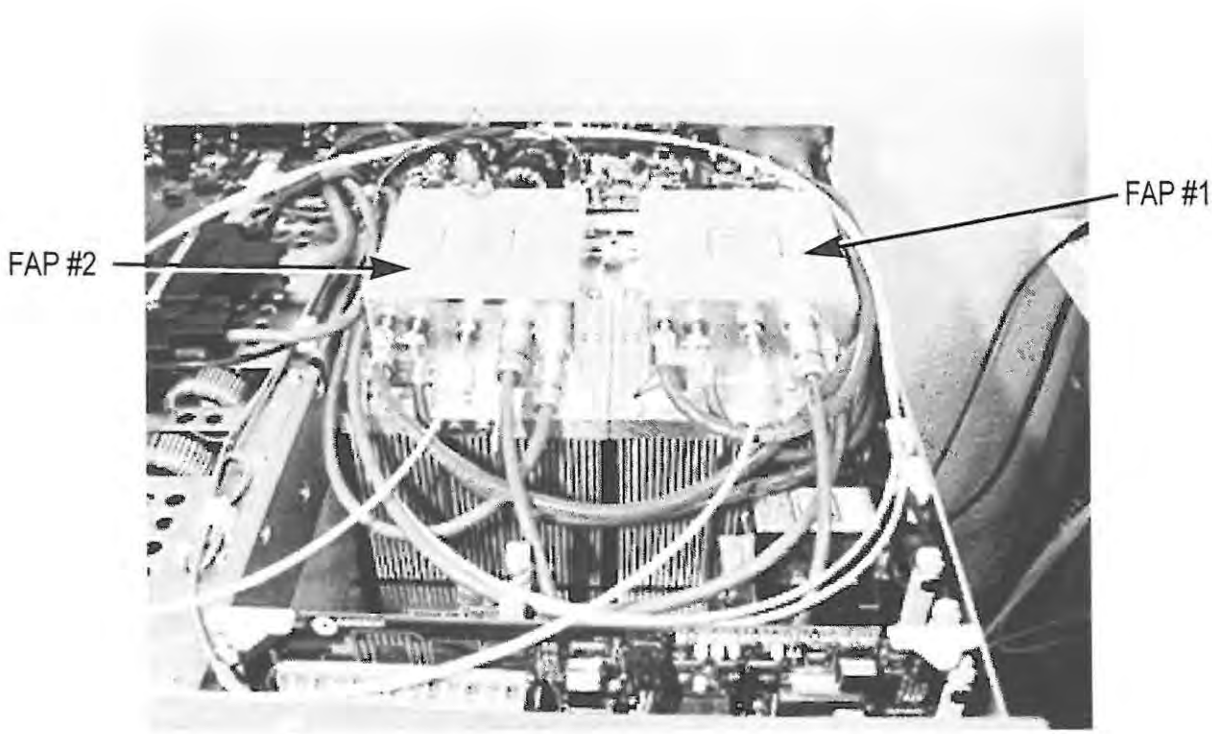


Figure 5-1. Location of FAP-I Assemblies

2. A shorting clip (Figure 5-2) must be installed between the anode and cathode terminals to avoid inadvertent ESD before the leads are disconnected from the terminals.
3. When disconnecting the fiber optic cable from the FAP-I assembly, a cap (Figure 5-2) should be installed over both the FAP-I optical emission port and the end of the fiber optic cable to protect them from accidental damage or contamination.

The end of the fiber optic cable constitutes an optical surface. Do not allow the end of the fiber optic cable to contact any surface including the fingers.

A contaminated optical surface can cause system damage. To minimize exposure to the environment, the blue protective plastic cap should be installed whenever the fiber is disconnected.

When removing or installing the fiber optic cable, do not allow the fiber optic cable to rotate while loosening the ferrule connector.

Figure 5-2. Fiber Optic Cap and FAP-I Anode/Cathode Shorting Clip

Fiber Cable Handling Precautions

1. When removing or installing a fiber optic cable, do not allow the fiber optic cable to rotate while loosening the ferrule connector (Figure 5-3).

2. The end of the fiber optic cable constitutes an optical surface. Do not allow the end of the fiber optic cable to contact any surface including the fingers. To minimize exposure to the environment, the protective plastic cap should be left in place until a connection is made and immediately installed over the fiber end when a connection is disassembled.

3. Do not allow the end of the fiber optic cable to contact the diode (FAP-I) assembly or any other surface including the fingers. Failure to do so can damage the optical surface.

Inspect the fiber optical surface to verify there is a need to clean prior to performing the cleaning procedure.

4. Do not install a contaminated or damaged fiber optic cable to the FAP-I. Doing so will cause a failure of the laser system. Contamination or damage can be difficult to detect. A magnifier will be helpful during examination.

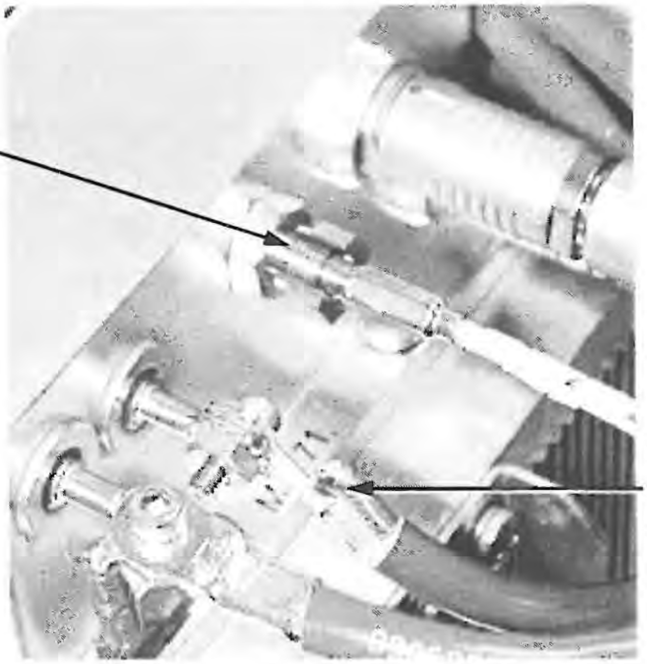


Figure 5-3. FAP-I Fiber Optic Connector

Do not use acetone as a cleaning solvent on the fiber optical surfaces. It will dissolve the matrix which supports the fiber and permanently destroy the optical transport fiber.

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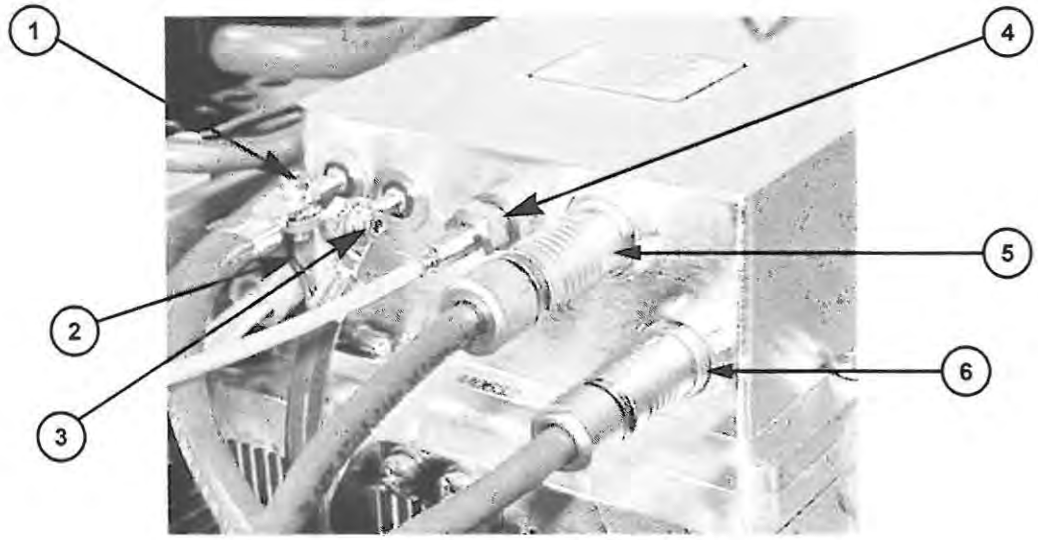
5. The end of the fiber optic cable should be cleaned using the drop and drag procedure located in the section titled, Cleaning the Optical Transport Fiber End Face. Do not use any other procedure or method. If scratches or other damage is noted, the FAP-I replacement should be terminated and the plastic cap reinstalled. Contact Coherent or an authorized local representative.
6. Excessively tight fiber umbilical bends (less than a 5 inch radius) can cause permanent damage.

FAP-I Removal

1. Install shorting clip (Figure 5-2) between anode and cathode of FAP-I assembly to be removed. Disconnect the anode and cathode connectors, see Figure 5-4.
2. Disconnect the Case/Anode ground jumper from the FAP-I assembly.



1. Anode Connector
2. Case/Anode Ground Jumper
3. Cathode Connector
4. Fiber Optic Connector
5. Personality Module, Thermistors, Head Hours Connector
6. TEC Coolers Inputs/Outputs Connector

Figure 5-4. FAP-I Assembly Interface

Wear finger cots (supplied with the replacement FAP-I) while handling the fiber optic cable.

3. Disconnect the fiber optic cable as follows:

   a. While firmly holding the fiber optic cable, loosen the ferrule connector securing the fiber optic cable to the FAP-I. It may be necessary to use a small wrench to loosen the connector.

   b. Note that the ferrule is cutout, see Figure 5-3. Carefully extract the fiber optic cable from the FAP-I and remove the ferrule. Immediately install the two plastic protective caps, one over the end of the fiber cable and the second over the FAP-I optical output port (Figure 5-2).

4. Disconnect the Personality module and TEC connectors from the FAP-I assemblies by pulling back on the outer sleeve and then unplugging the connector.

5. Remove eight screws securing the FAP-I to the heat sink (two on each side).

Due to the thermal grease on the bottom of the FAP-I assembly, it may be necessary to work the old assembly loose by rotating (wiggling) it back and forth around its center.

6. Remove the FAP-I and clean the thermal grease from the FAP-I and the mounting surface (alcohol works well for this).

FAP-I Installation

1. Remove the new FAP-I from the shipping container. Leave the shorting clip and protective plastic cap in place to avoid possible ESD and contamination damage, respectively. The new diode should also come with a die-cut plastic masking sticker, a tube of thermal compound, a plastic spatula for spreading the compound, a fiber cap, and a finger cot for handling the fiber.
2. Apply the die-cut template to the bottom of diode to avoid getting thermal compound in the screw holes in the next step. Alternatively, place masking tape over the edges of the FAP-I baseplate as illustrated in Figure 5-5.
3. Using the plastic applicator, apply an even coating of thermal grease to the bottom of the FAP-I. The thickness of the grease film should be less than the thickness of the masking tape or template.
4. Position the FAP-I assembly on the heat sink and reattach the Case/Anode ground jumper to the FAP-I baseplate.
5. Secure the FAP-I to the heat sink using the remaining seven mounting screws. Remove any excess thermal grease from around the assembly.

After connection, the red anode lead should be horizontally oriented and the black cathode lead should be vertically oriented. This is illustrated in Figure 5-3 and is done to minimize the potential of generating/picking-up EM noise.

6. Re-connect the anode and cathode leads. Be sure to reconnect the case/anode ground jumper when connecting the anode lead. Remove the anode/cathode shorting clip.
7. Re-connect the Personality module and TEC connectors, and reconnect the fiber optic cable.

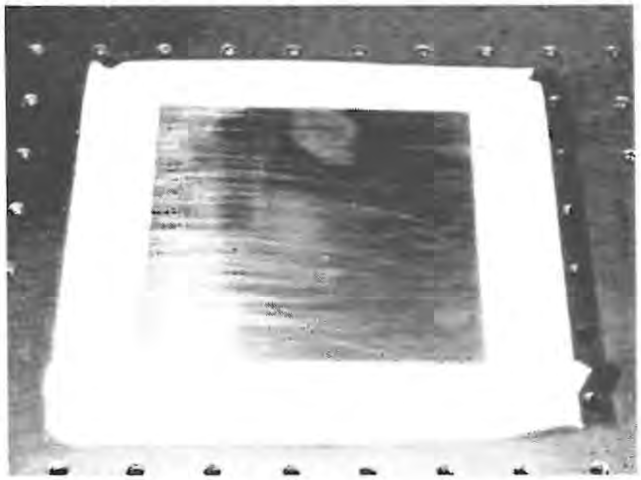


Figure 5-5. Preparation of the Replacement FAP-I Assembly

8. If disconnected, connect the power supply power cord to facility power. If a ground wire was used, remove it.
9. Replace the power supply cover and perform the cold start turn-on procedure.
10. Verify system parameters.

Cleaning the Optical Transport Fiber End Face

In the event that the optical transport fiber end face becomes contaminated, use the procedure outlined below to clean the end face.

This procedure should not be required as part of normal operation. If the fiber end face becomes continually contaminated, contact 1-800-367-7890 or your local Coherent representative.

1. Hold the fiber by the connector or cable as shown in Figure 5-6. Place a drop of spectroscopic grade methanol in the center of a lens tissue. Place the wet portion of the lens tissue on the optical surface and slowly drag it across the surface.

Figure 5-6. Cleaning the Optical Transport Fiber End Face

Do not use acetone as a cleaning solvent on the fiber optical surfaces. It will dissolve the matrix which supports the fiber and permanently destroy the optical transport fiber.

2. Examine the surface of the optic using a magnifier. If streaks or contamination remain, repeat the process using a fresh lens tissue.
3. Immediately install the end face into the FAP-I or place a protective cover over the end face to avoid further contamination.

LBO Temperature Optimization

The conversion efficiency of the LBO frequency doubler is heavily dependent upon temperature. A temperature change of 1°C can reduce the doubling efficiency by greater than 50%. Coherent's experience in dealing with non-critically phase- matched LBO has shown that it is essential to re-adjust the phase-matching temperature. The Vitesse software has a menu routine that will automatically perform LBO temperature optimization to maximize the conversion efficiency of the doubler.

The purpose of the LBO temperature optimization is: as the optimum phase-matching temperature changes in the LBO, the green output power will decrease for a given diode current. In light regulation, to compensate for the reduced efficiency the laser will drive the diodes harder (more current) to produce the desired 532 nm output. This will reduce the lifetime of the diodes.

The LBO Optimization routine should be run when diode current is observed to be 10% greater than baseline values.

Performing Optimization:

1. Turn Vitesse On at a power level that is typically used.
2. Scroll to the LBO Optimization Menu and select the optimization routine.
3. Once selected the LBO temperature will be increased and decreased with the software recording the Vitesse Output Power at each LBO temperature. (This routine is performed with a constant diode current.)
4. Optimum LBO temperature will be determined based on the Vitesse Output Power vs. LBO Temperature curve.
5. This temperature will be stored as the new LBO temperature set point.
6. LBO optimization requires approximately 20 minutes.

Fuse Replacement

Criteria for Replacement

Defective fuse per Chart 1.

Do not turn off the power switch or disconnect the AC power input until the cool down cycle is complete.

---

1. Perform the "Turn-off (Complete Shut-Down)" procedures located in Section Three, Operation. The associated cool-down cycle will take approximately 45 minutes. The front panel display will indicate when the cool-down cycle is complete.
2. Turn off the power switch on the power supply rear panel and disconnect the power cord from facility power.

A fuse that repeatedly fails is an indication of a more serious problem. In this case, the system should be returned to the factory. If the laser system or components are being returned directly to Coherent, an RMA (Return Material Authorization) number is required. Contact Coherent or an authorized representative.

3. The location of the fuse is shown on Figure 3-2. Insert a small screwdriver and twist to remove the fuse holder.
4. Replace the fuse with a 10A, 250V, time delay fuse and reinstall the fuse holder. Connect the power supply power cord to facility power.
5. Perform the "Turn-on (Cold Start)" procedures located in Section Three, Operation.

Verification of Successful Installation

6. The AC ON indicator on the power supply front panel will light.

Battery Replacement

The battery in the power supply is not user replaceable. Contact Coherent or an authorized representative if the battery requires replacement.

Cleaning the Air Filter

The air filter is located on the power supply rear panel as shown on Figure 3-2.

Criteria for Cleaning

Visual inspection on a periodic basis. Inspect more frequently if the operating environment is less than ideal.

Clean the air filter when the laser is turned off.

Removal

Do not turn off the power switch or disconnect the AC power input until the cool down cycle is complete.

Do not remove the air filter while the fan is running. The fan is operational when the key switch is in the STANDBY position.

---

1. Perform the "Turn-off (Complete Shut-Down)" procedures located in Section Three, Operation. The associated cool-down cycle will take approximately 45 minutes. The front panel display will indicate when the cool-down cycle is complete.
2. Turn off the power switch on the power supply rear panel and disconnect the power cord from facility power.

Air Filter Removal and Cleaning Procedure

3. Loosen the two retaining nuts (Figure 3-2, item 17) and remove the air filter.
4. Clean the air filter by rinsing with water and dry with a blower.
5. Re-install the air filter and perform the "Turn-on (Cold Start)" procedures located in Section Three, Operation.

Verification of Cleaning

6. Visual inspection.

SECTION SIX: INSTALLATION

Receiving and Inspection

Inspect shipping containers for signs of rough handling or damage. Indicate any such signs on the bill of lading. Report any damage immediately to the shipping carrier and to Coherent Order Administration Department (800-438-6323) or to an authorized representative.

Retain shipping containers. The containers will be required if the system is returned to the factory for service. The containers may also be needed to support a shipping damage claim.

Four people are recommended to unpack and transport the Vitesse. The power supply which weighs 75 pounds should be lifted by two people while the laser head which weighs 87 pounds can be lifted by the other two. The laser head and power supply are connected by the umbilical.

External Interlock

The system will not operate with the interlock open. An interlock connector is located on the power supply rear panel. The interlock status is monitored by the CPU. If the interlock is open, a message will be displayed on the power supply front panel.

An external interlock circuit can be connected to the laser system and wired to a door switch to provide additional operating safety. When the door is opened, the laser will shut down. Press MENU EXIT key to clear the fault and continue operation.

To incorporate an external safety interlock circuit into the laser system, perform the following steps:

1. Turn off the laser system. Locate and remove the Interlock connector from the back of the Verdi power supply. This type of connector is called a "three pin mini-DIN".
2. Slide the plastic cover off of the connector. Locate the two pins that have a wire soldered between them. These are pins 1 and 2. Remove the shorting wire and solder your interlock wires to these two pins. Make sure the wires have adequate strain relief.
3. Solder the other ends of the wires to an interlock switch. You can use many types of switch. The switch must be of a type that

has its contacts **closed** when it is safe to operate the laser and open when it is not safe.

4. Figure 6-1 shows the wiring diagram for the switch. One wire runs from pin 1 of the connector to the normally open contact of the switch. The other wire runs from pin 2 to the common terminal of the switch. The switch is shown in the open position. This is the condition where you do not want the laser beam to operate.

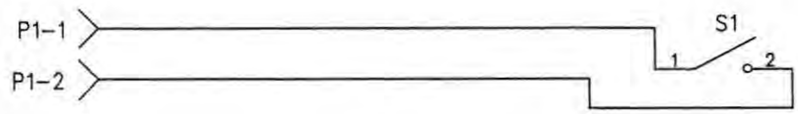


Figure 6-1. External Interlock

5. The interlock circuit in Verdi operates from a +/-12 VDC circuit. Its current is limited to around 1 milliAmpere. For these ratings a "dry circuit" type switch will give the most reliable operation.

Installation

Locate the laser head and power supply in a convenient location, preferably away from heat producing sources. Ensure the power supply cooling intake and exhaust (rear, top, and left side) are not blocked or obstructed. Ensure the umbilical is not twisted or kinked. Do not exceed a bend radius of 5 inches.

Excessively tight umbilical bends (less than a 5 inch radius) can cause permanent damage.

Each locality should inspect the power cord and install the proper connector if necessary. The connector should be installed in a properly grounded outlet with a maximum of 16 Ampere service for proper overcurrent and earth fault protection.

1. Connect power supply to facility power.
2. Perform the cold start procedure located in Section Three, Operation.

Cooling Water – Laser Head

It is recommended to connect the laser head to a source of cooling water, such as a Thermotek (model number T-251P), or equivalent with the specifications indicated below. Best performance is achieved when the baseplate temperature is controlled to 25±1°C. Failure to connect the cooling water may result in a serious degradation of the output power and bandwidth characteristics.

Cooler Requirements:

Maximum flow rate	0.4 gal/min.
Maximum pressure	30 psi
Maximum water temperature	25°C
Heat sink thermal removal	5 Watts (typical)

Table 6-1. Utility Requirements

PARAMETER	REQUIREMENT
Power Requirements	90 to 250 VAC[1][2]
Maximum Current	Max. 14.5 Amp @ 90 VAC
Line Frequency	47 to 63 Hz
Cooling	Power supply: Air cooled with ambient air. Laser head: Water cooled.

Note: All specifications and requirements are subject to change without notice.

[1] The power supply is autoranging and will accommodate the full range of input voltages without hardware changes.

[2] The electrical service should have a main power disconnect switch located in close proximity to the laser. The main power disconnect switch shall be clearly marked as the disconnecting device for the laser, and shall be within easy reach of the operator.

Table 6-2. Environmental Requirements

PARAMETER	REQUIREMENT
Operating temperature	15 to 30°C (59 to 86°F)
Relative humidity	5 to 95% non condensing
Altitude	Sea level to 10,000 feet

Table 6-3. Dimensions and Weights

	POWER SUPPLY	LASER HEAD	UMBILICAL
Length	45.09 cm (15.75 in)	53.02 cm (20.88 in)	3 meters (10 feet)
Width	43.51 cm (17.13 in)	33.02 cm (13.0 in)	——
Height	17.78 cm (7.0 in)	13.89 cm (5.47 in)	——
Weight	31.5 kg (75 lbs)	43.2 kg (87 lbs)	1.8 kg (4 lbs)
Diameter	——	——	3.75 cm (1.5 in)

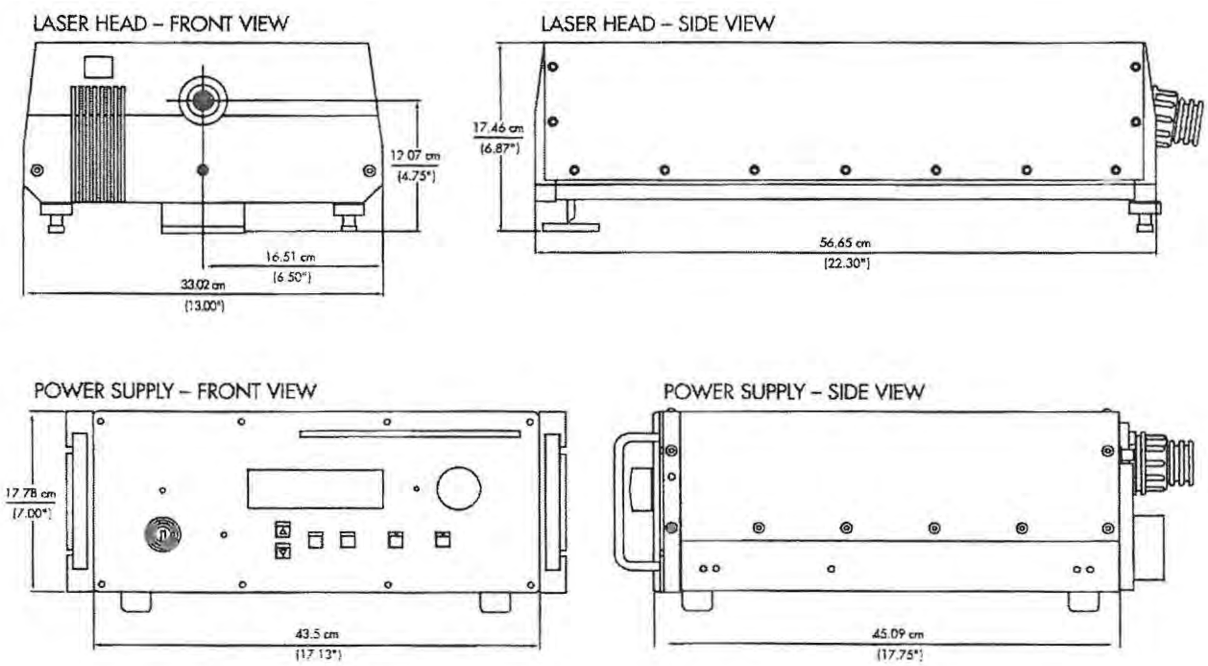


Figure 6-2. Dimensions

SECTION SEVEN: PRINCIPLES OF OPERATION

Vitesse Laser Head

The Vitesse laser head (Figure 7-1) consists of a Verdi laser, a PowerTrack mirror, and a Verdi Pumped Ultra-Fast (VPUF) laser. The 532 nm output from the Verdi pumps the VPUF.

Optimum pump beam (532 nm) alignment is provided by the PZT controlled mirror. This pump optimization is known as PowerTrack. The output from the VPUF is then directed, with two steering mirrors, through the exit port of the Laser Head. This allows for the exact exit beam positioning that is achieved with each Vitesse Laser System. The Verdi laser head, PowerTrack function, VPUF laser head, and the power supply are described in the following paragraphs.

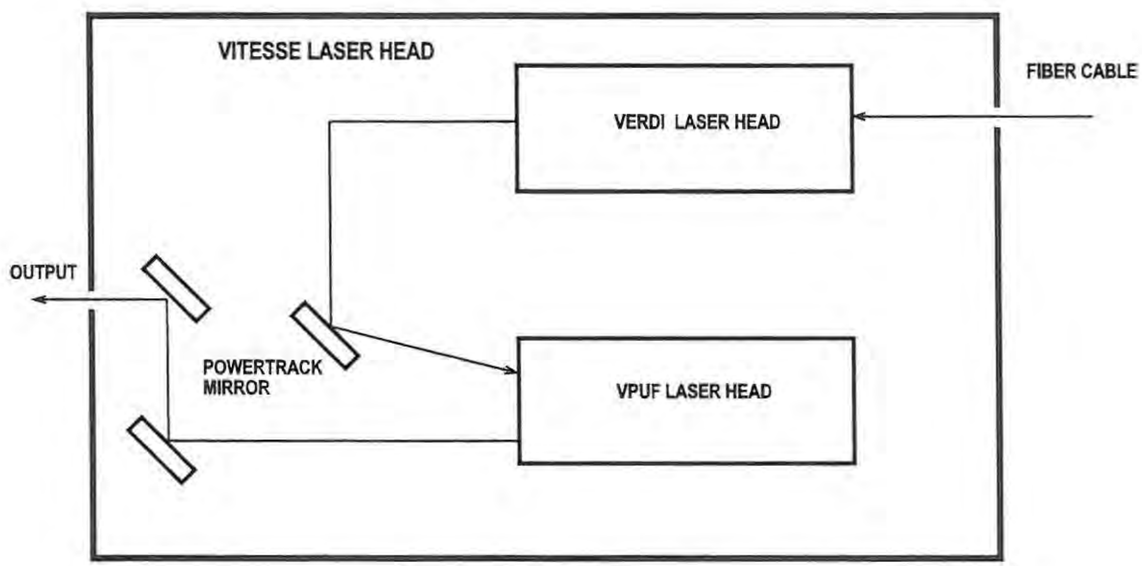


Figure 7-1. Vitesse Laser Head Schematic

Verdi Laser Head

The pump laser resonator is a robust unidirectional single-frequency ring cavity design employing intracavity second harmonic generation to produce multi-watt-level continuous-wave green (532 nm) visible light output. Permanently aligned within a clean-room manufacturing environment, the resonator optics are rigidly mounted upon a proprietary grade Invar™ slab. These optics are mounted using Coherent's exclusive PermAlign™ manufacturing process, resulting in a permanently aligned resonator structure that's completely immovable–and stable.

Coherent-grade Super Invar™ combines a true zero coefficient of thermal expansion at room temperature with a high specific heat capacity, resulting in a resonator superstructure with extraordinarily good passive thermal stability. The Invar slab is kinematically mounted to the laser head base plate, minimizing the influence of external mechanical forces upon the resonator alignment. The aligned assembly is housed within a sealed enclosure to isolate optical components from exposure to environmental contaminants.

Unidirectional oscillation in a ring laser resonator design is essential to establish and maintain reliable single-frequency operation through the elimination of spatial hole-burning. In the pump laser, single-direction lasing is accomplished with an intracavity optical diode that induces lower losses for light traveling around the ring in the preferred direction in comparison to the counter-propagating direction. The single-frequency selectivity associated with unidirectional oscillation is further enhanced with a temperature-stabilized intracavity etalon. The pump laser resonator also incorporates a Brewster-plate compensator to eliminate the astigmatism associated with the use of spherically curved mirror surfaces at non-normal incidence angles.

The pump laser resonator can be categorized as an "end-pumped" design, in which the pump light from the diode bar propagates collinear to the optical axis within the gain medium. Careful control of the spatial overlap between the mode volume defined by the resonator geometry and the actively pumped volume of the gain medium constrains laser oscillation to the lowest-order transverse mode (TEM_{00} mode operation). Transverse mode control is consequently achieved without the need for "hard" apertures that can introduce many undesirable characteristics, including beam distortions through diffraction effects, lowered efficiency, and lower pump-diode lifetimes.

Verdi Gain Medium

The pump laser gain medium is Nd:YVO_4 (Neodymium: Yttrium Orthovanadate), commonly referred to as Vanadate. Vanadate's high absorption coefficient at the 808 nm pump wavelength (a standard wavelength for high powered diodes for laser pumping) and large stimulated emission cross section near 1064 nm make it an ideal choice for the pump laser.

Among Nd:YAG, Nd:YLF and Nd:YVO_4 as laser materials, Nd:YVO_4 has the highest absorption coefficient which allows a shorter crystal length. In addition, Nd:YVO_4 has the highest stimulated emission cross section, almost four times larger than Nd:YAG. Vanadate also maintains a strong single-line emission around 1064 nm.

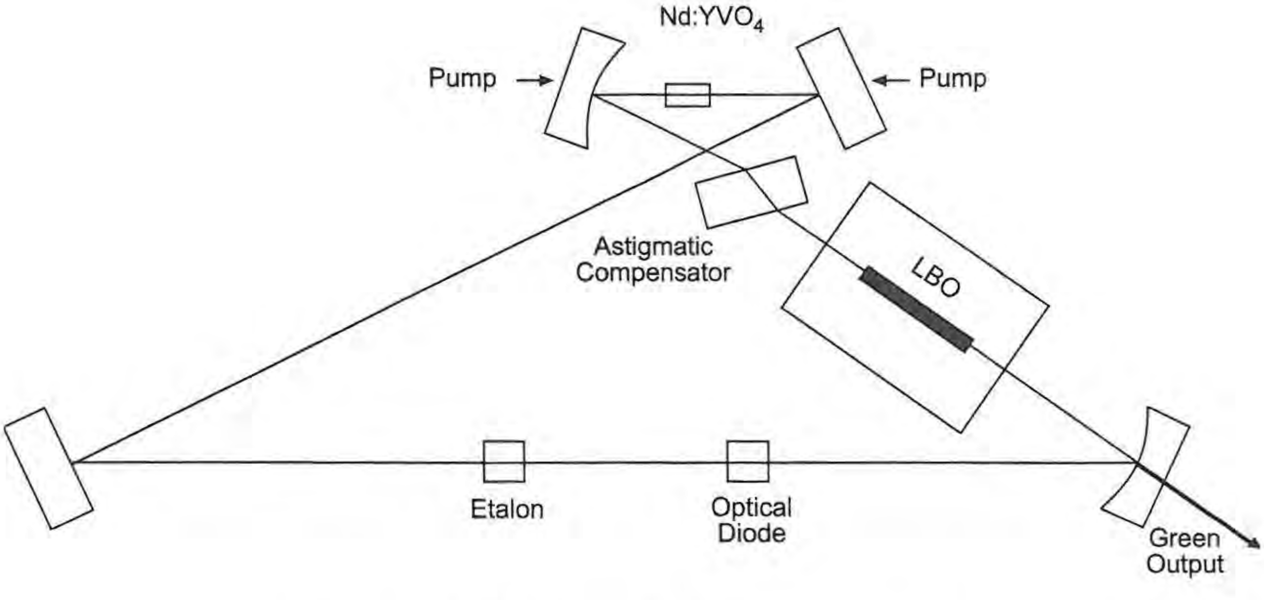


Figure 7-2. Verdi Laser Head Optical Schematic

Vanadate is a uniaxial material that produces a polarized laser output, thus avoiding undesirable thermally induced birefringence. Optical properties are dependent on crystallographic direction. Material properties like thermal conductivity, index of refraction and thermal expansion are different in directions parallel to the crystallographic axis and perpendicular to it. This anisotropy heavily impacts the optical design.

Verdi Thermal Focusing Characteristics

An optically-pumped laser rod acts as a lens inside the laser resonator. The thermal gradient causes strain in the rod, which also contributes to focusing.

In Nd:YVO_4, for light polarized perpendicular to the optical axis, there are two focal lengths. One value for rays in a plane containing the optical axis and another value for rays in the perpendicular plane.

For light polarized parallel to the optical axis, there are two focal lengths. The four values of focal length are all different. The pump laser is polarized parallel to the optical axis. The material is said to show astigmatism when, for a given polarization, there are two focal lengths.

In the pump laser, the Vanadate is temperature regulated in a configuration that minimizes thermal focusing, therefore reducing the astigmatism.

Verdi Second Harmonic Generator

LBO is used as the second harmonic generator. LBO takes advantage of higher intracavity powers. Intracavity power is greater than output power by a factor of 1/T where T = transmission of output coupler. LBO crystal acts like an output coupler. The cavity uses two high reflectors to reach highest fundamental intracavity power.

The advantages of LBO are:

- Low absorption across the visible and infrared.
- High damage threshold.
- Non-hygroscopic

LBO is a Type I, non-critical phase matching medium. The condition of phase matching occurs when the second harmonic and fundamental travel through the crystal at the same velocity. In Type I phase matching, the fundamental propagates as an e-ray and is perpendicular to the second harmonic which is an 0-ray.

Verdi – 90° Phase Matching

The fundamental wavelength propagates 90° to the optic axis. In this case, phase matching can be accomplished by temperature tuning. The fundamental wavelength of LBO at 1064 nm is phase matched with the second harmonic wavelength of 532 nm at a crystal temperature of approximately 148°C. The advantages are:

- No dependence of conversion efficiency on beam divergence.
- No double refraction occurs. The fundamental won't walk off the second harmonic and longer crystals can be used to increase efficiency.

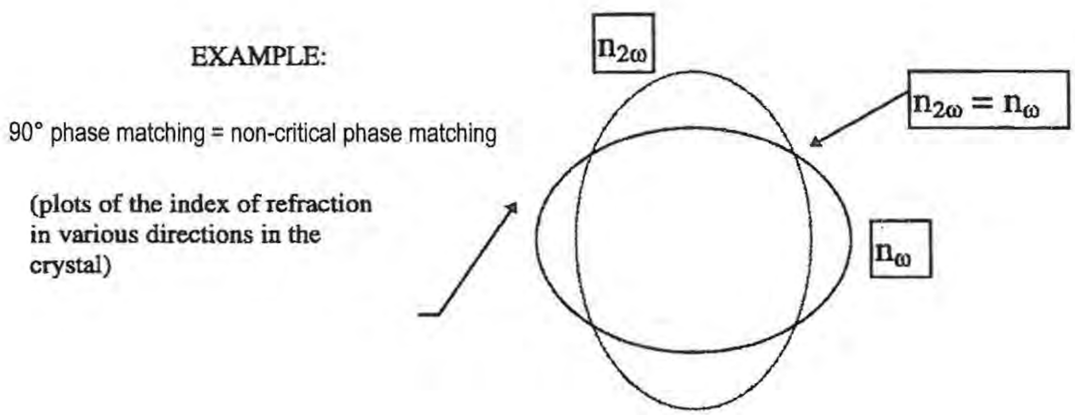


Figure 7-3. Index of Refraction Surfaces (Verdi)

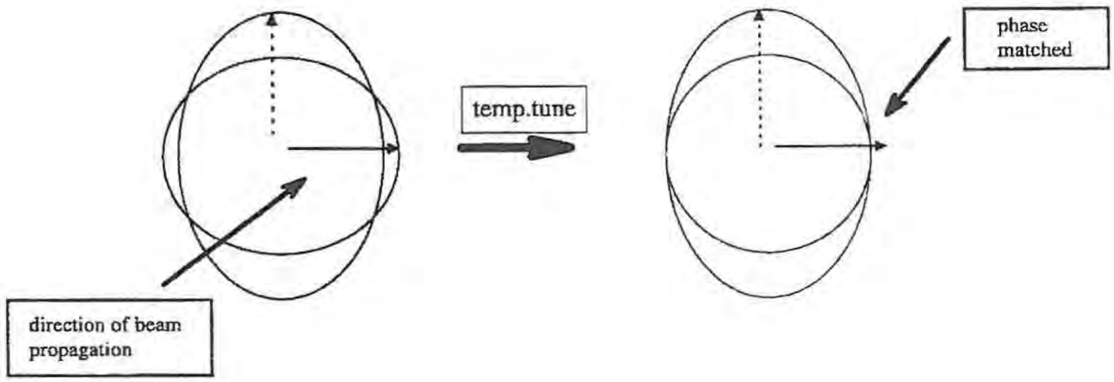


Figure 7-4. 90° Phase Matching (Verdi)

LBO Temperature

Temperature control of the LBO is critical since the optical coatings cannot tolerate rapid temperature changes. The LBO is heated to a temperature of approximately 148°C under control of the main CPU. This temperature is maintained as long as the power switch on the rear of the power supply is set to On. The correct procedure for shutting down the pump laser is described in Section Three, Operation.

The power switch on the rear of the power supply should be left on for approximately 45 minutes after the LBO cool-down has been initiated to avoid unnecessary use of the internal battery.

A slow heater ramp-up cycle is initiated when the power switch is turned on. A slow cool down cycle is executed when the cool down cycle is activated in the "LBO Settings" menu. The laser diodes will not be turned on until the LBO reaches the proper operating temperature. Refer to the turn-on and turn-off procedures in Section Three, Operation.

The power supply has a battery backup circuit that executes a slow, CPU controlled cool down procedure in the event of a sudden AC power loss.

The power switch on the power supply rear panel should not be used to shut the system down without performing the shutdown procedure via the power supply display. Doing so will cause the battery to be used (rather than AC power) for LBO cool-down. The battery is re-chargeable but eventually will have to be replaced. The battery is charged when AC power is applied to the power supply.

PowerTrack

The PowerTrack function actively maintains optimum pump beam alignment into the VPUF cavity serving to minimize fluctuations in the Ultrafast output power. PowerTrack works as follows:

Piezo Electric Transducer driven levers alter the tilt, and hence pointing, of the PowerTrack mirror shown in Figure 7-1. In StandBy, there is no voltage provided to the levers. Once the system is keyed to the "Laser On" position, the PZT controller provides voltage to these levers which functionally begins a Raster Scanning of the mirror in the X and Y directions (large changes in PZT voltage and hence pump beam position).

This Raster Scanning can be observed as large changes in the PZTx and PZTy voltages in the PZT Control submenu. Once a preset threshold level of CW lasing is achieved the Raster Scan is switched to a smaller amplitude Dither Scan (smaller changes in PZT voltage and hence pump beam position).

The Dither scan is centered about the Raster Scan voltages found to achieve the threshold level of CW lasing. System electronics then distinguish increases in power with changes in PZT voltage (pump beam alignment). This allows the Dither Scan to fine tune the PZT voltage in the direction needed for optimum pump beam alignment.

VPUF Laser Head

The VPUF is an Ultrafast cavity that uses Ti:Sapphire as the gain medium. The proprietary Negative Dispersion Mirrors (NDM) provide the negative dispersion. Multiple reflections from the NDMs provide the total negative dispersion compensation that is required to produce sub-100 femtosecond pulses. Modelocking is obtained using the Kerr-Lens Modelocking (KLM) technique with an automatic starter triggering the initiation of modelocking. The VPUF is built on an invar plate for mechanical strength and stability and is hermetically sealed to reduce environmental contamination.

Kerr Lens Modelocking

The Vitesse cavity has been designed so that the beam diameter within the cavity changes by a small amount as the intensity of the light changes. More specifically, the beam diameter at certain locations within the cavity is large when the laser is operating continuously (CW) but becomes smaller when the laser is producing high intensity modelocked pulses.

A slit is placed at the appropriate location so that the large diameter laser beam associated with continuous wave operation will be interrupted at its edges. A high intensity pulse, however, will pass uninterrupted through the slit, since this beam is smaller. Therefore, higher intensity beams will experience less loss than lower intensity beams. Refer to Figure 7-6.

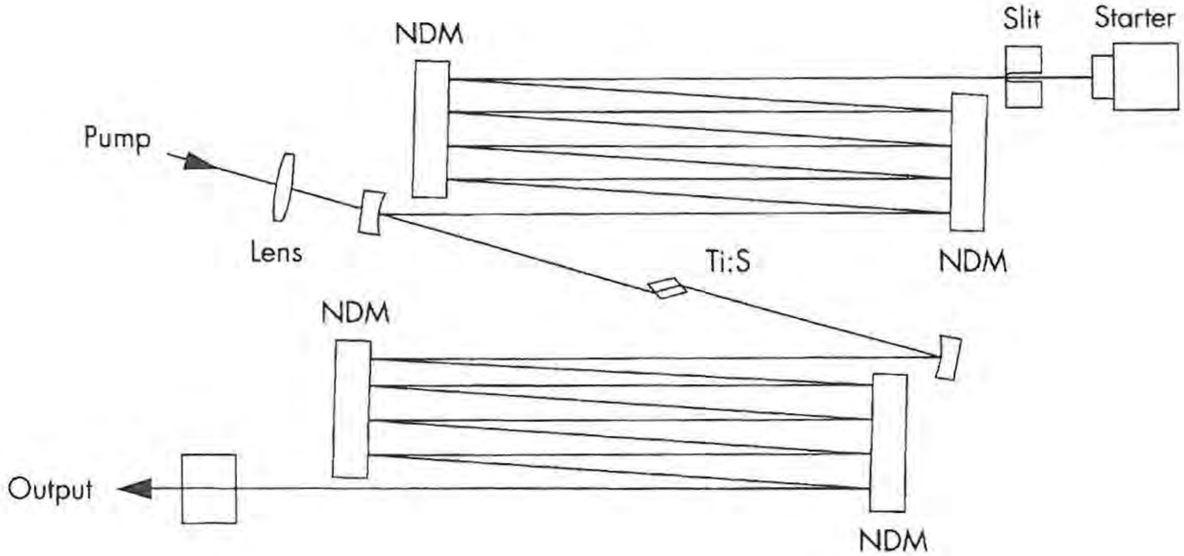


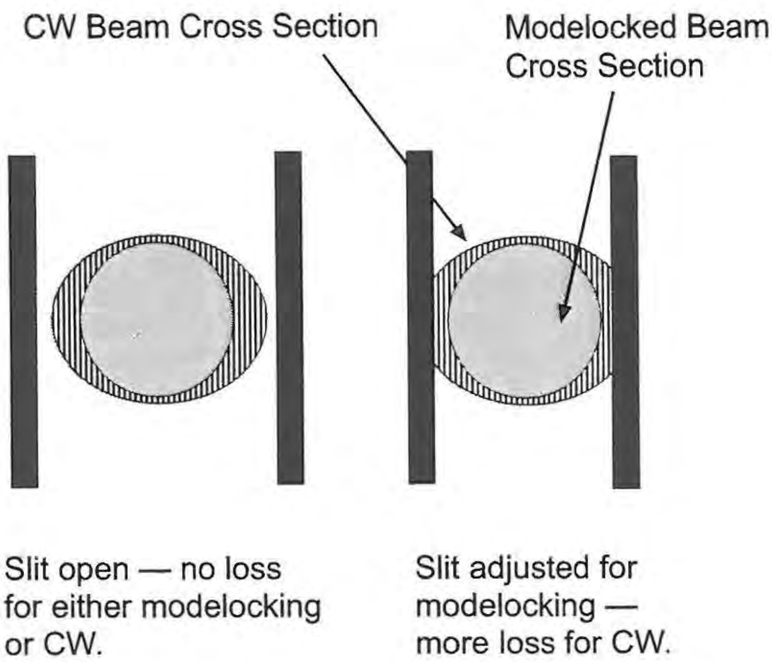
Figure 7-5. VPUF Laser Head Schematic

The modelocking device in Vitesse consists of two parts.

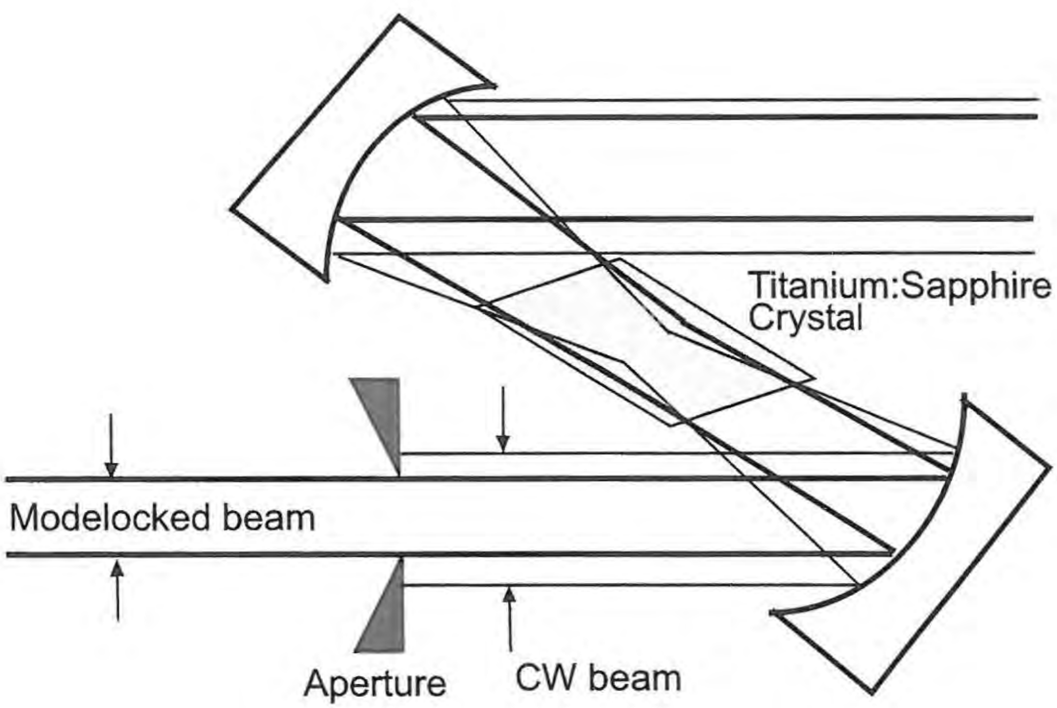
1. A material which decreases the laser beam size in the presence of high intensity pulses.
2. The slit which introduces losses for large beams.

The properties of light passing through any material depend, among other things on a property referred to as the index of refraction, or *n*. The higher *n*, the lower the velocity of light. If the velocity of light is different for different parts of the light beam, the beam will bend or otherwise be reshaped, since different parts of the beam are travelling at different speeds. This is known as refraction. A common refractive element is the lens (e.g., a biconvex lens), which is thicker in the middle than at the edges, so that the center of the beam is slowed down more than the edges. This causes the light to bend toward the center. In the case of the lens, the index is the same everywhere; however, since there is more glass in the middle than the edges, the edges are slowed down less. A lens can also be formed by making the index of refraction at the center of a material larger than the index at the edges. This will also bend light and is referred to as a gradient index lens.

The most common way to change the index of a material is to change its chemical composition. However in Vitesse, the index is changed by the light itself. At sufficiently high intensity, the electric fields associated with the light can actually distort the atoms of the material and alter its index. This effect is known as the optical Kerr effect.



A. BEAM CROSS SECTION



B. BEAM GEOMETRY

Figure 7-6. Kerr Lens Modelocking

Since the beam is less intense at its edges as compared to the center, the index at the center will be different, and a gradient index lens is formed. Since it is the optical Kerr effect which alters the index, the lens thus formed is referred to as a Kerr lens. The Kerr lens is formed only when the intensity of the light is extremely high. The instantaneous intensity of modelocked light pulses is sufficient to form this lens, while the lower intensity of the laser operating CW is not. Hence the lens is only formed upon the arrival of a modelocked pulse. It is this lens which narrows the laser beam and, consequently, a mechanism has now been created which narrows the beam only for modelocked pulses. The addition of a slit to allow only narrow beams to pass unattenuated now forms the complete system which provides the real driving force for modelocking.

The Starting Mechanism

Normally, the laser will operate in the CW mode with minor power fluctuations none of which cause, even instantaneously, powers which are sufficiently high to cause a Kerr lens to form. Hence, some mechanism must be introduced to create sufficiently high peak powers. By changing the cavity length at the proper speed, very high power fluctuations can be induced. Once the instantaneous power in one of these fluctuations becomes sufficiently high, a Kerr lens is formed, the beam is narrowed and can pass unattenuated through the slit. This pulse will become amplified and become the dominant pulse which will form the modelocked output.

Once a larger number of modes are lasing, high peak intensities are produced to initiate Kerr lens formation and the modelocking process begins.

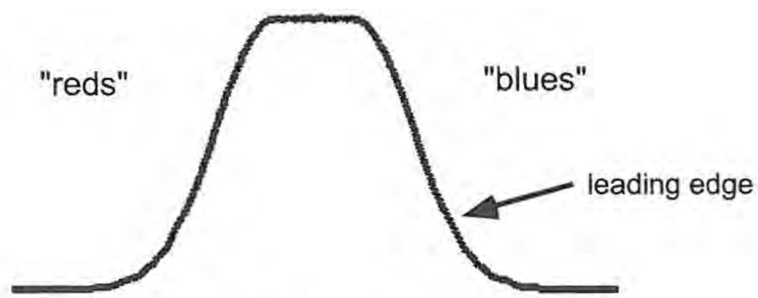
It is important to mention that once modelocking starts, it will continue without the need of the starting mechanism. The rapid length variation can be halted.

The length of the cavity is changed by increasing the distance between the mirrors. This is accomplished by mounting the high reflector end mirror on a solenoid driven spring.

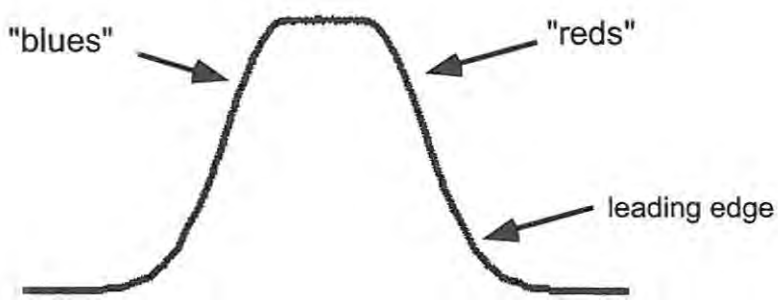
Group Velocity Dispersion

An ultrashort laser pulse consists of a distribution of wavelengths. The spectral width of the distribution is inversely proportional to the temporal length of the pulse. In addition, to produce a short laser pulse the timing, or phase, between each component wavelength must be precisely correct. It can be demonstrated that an ultrashort pulse will become temporally longer after it has passed through optical glass. This is because the index of refraction, and hence the speed of light in the material, depends nonlinearly on the wavelength.

Group velocity dispersion causes temporal reshaping of wave packets—this can be a broadening or a shortening shape change depending upon the initial conditions (chirp) of the wave packet spectrum. The term "chirp" means the spectral components of the pulse have become out of phase. Referring to Figure 7-7, we see that a pulse is said to be positively chirped if its instantaneous frequency increases from leading edge to trailing edge. This is the type of chirp which will normally be imparted to a pulse after traversing "normal" materials. Its blue spectral components will be retarded with respect to the red, creating a systematic variation of phase with respect to wavelength. Similarly, a pulse is said to be negatively chirped if its red spectral components have been retarded with respect to the blue as seen in Figure 7-7.



A. NEGATIVE CHIRP — BLUE FREQUENCY COMPONENTS LEAD THE REDS (RESULTS FROM –GVD)



B. POSITIVE CHIRP — RED FREQUENCY COMPONENTS LEAD THE BLUES (RESULTS FROM +GVD)

Figure 7-7. Group Velocity Dispersion

Self Phase Modulation

In addition to the phenomena already described (GVD), pulses in ultrafast lasers are also affected by self-phase modulation (SPM). Intense light pulses propagating through dense media create a local index of refraction that is dependent on the light field intensity. This phenomenon is known as the optical Kerr Effect. A result of the optical Kerr effect is that the leading and trailing edges of the pulse

will produce different (i.e., less) change in the index of refraction than the center of the pulse where the intensity is highest. This will lead to parts of the pulse moving faster, and thus altering the pulse shape. Frequency components propagating through the material are thus phase shifted differently depending upon when they occur in the pulse. This phenomena actually generates new frequencies (or eliminates old ones depending upon the initial conditions). These frequency components are inherently chirped and can broaden the pulse unless the chirp is compensated. It can be shown that chirp which results from SPM has the same sign (positive) of the chirp introduced through normal material GVD.

Dispersion Compensation

Self-Phase Modulation and GVD arise from the many dispersive elements within a laser cavity. Therefore, each time the pulse traverses the cavity a slight chirp, or frequency dependent phase shift, is imparted from these dispersive elements. To counter this chirp, a method must be employed that allows the various frequency components of the modelocked pulse to reestablish phase coherence. Without compensation, the cumulative effect of even a very small chirp per round trip can create broadening and pulse substructure. An element or system of elements possesing a net negative GVD is thus required to produce diffraction limited pulses.

Negative Dispersion Mirrors

The Group Velocity Dispersion compensation scheme of the Vitesse operates as follows. A modelocked pulse is formed and chirped by self-phase modulation and GVD in the various intracavity components of the laser. The chirped pulse enters NDM mirror 1 (modeled by a simple F-P interferometer in Figure 7-8) where it undergoes multiple reflections from the high-reflectance rear surface. If the thickness of the interferometer is kept small the transit time of the interferometer will be significantly less than the initial pulse width allowing for interference between the successively reflected waves.

It can be shown that:

$$\tan\,\phi = \frac{(1-r^2)\sin\omega t_0}{2r-(1+r^2)\cos\omega t_0}$$

Where:

γ^2 = reflectivity from front surface of etalon
t_0 = transit time through etalon
ϕ = phase shift
ω = angular frequency

Because the interferometer is thin (several wavelengths), the change in transit time as a function of wavelength is negligible. Therefore, the phase delay or shift can be reduced to a function of frequency or wavelength. Because the group or phase delay is wavelength dependent, it is possible to show that the second derivative of this function provides the necessary negative Group Velocity Dispersion.

$$= \frac{-2t_0^{\,2}(1-r^2)r \sin \omega t_0}{(1+r^2-2r\cos \omega t_0)^2}$$

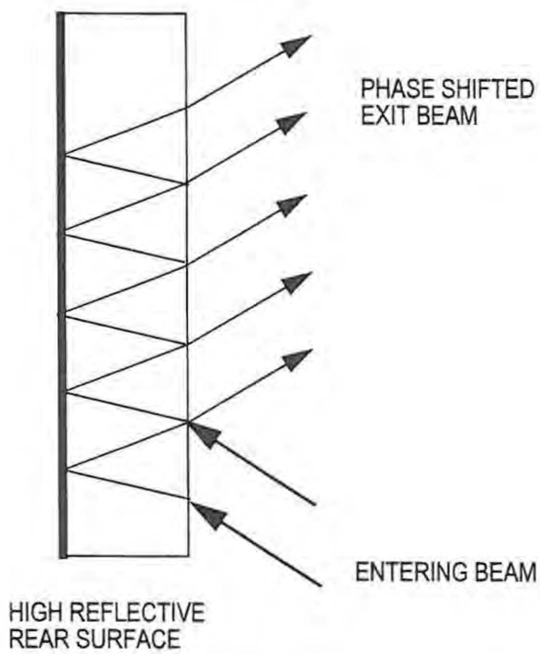


Figure 7-8. GVD Compensation

The technique of using a Gires-Tournois Interferometer to provide negative Group Velocity Dispersion is commonly used in pico-second ultrafast laser systems. In these pico-second systems the wavelength range or spectral width is smaller than that of femptosecond pulses. Therefore, in order to make the Vitesse NGVD mirrors work over the expanded femptosecond bandwidth a novel design of the dielectric mirror was required to provide wavelength dependent dispersion over a 150 nm bandwidth. These mirrors use multiple-layer dielectric coatings whose proprietary structure has been designed to produce extremely high reflectances (>99.95%) and the necessary wavelength dependent phase delays. By using

four NDM mirrors in the optical cavity sufficient GVD compensation can be attained to bring the net cavity GVD close to zero. Figure 7-8 shows only one mirror for simplicity.

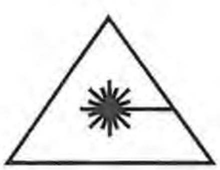
Power Supply

The power supply houses several circuit boards, an internal commercial power supply, two laser diode assemblies, and cooling fans. The power supply provides the following functions for the pump laser:

- Provides a light source (pump) for the gain medium in the laser head cavity via a fiber optic in the umbilical. Light is generated by the laser diode assembly as described in the next paragraph.
- Provides a user interface. The user interface consists of the front and rear panel controls and indicators.
- Controls and monitors the servo loops in the laser. The controls and servo loops are:
    - TEC loops for Vanadate, Etalon, and diodes
    - LBO heater (monitor and control)
    - Light loop
    - Heat sink (monitor and control)
    - Baseplate temperature (monitor only)
- Provides a source of DC voltage for all system functions. The internal power supply provides +48 VDC which is distributed to the laser.

Laser Diode Assembly

The hermetically sealed laser diode assembly contains a FAP-I™ (fiber array package-integrated), a circuit board with an EEPROM, and a heat sink sensor.



Note that the laser diode assembly is capable of emitting laser light when the fiber optic cable is disconnected. Do not look into the output of the laser diode assembly.

The FAP-I consists of a laser diode bar with collection and symmetrizing optics mounted within an environmentally sealed package. The FAP-I efficiently converts a low-voltage, high-current electrical power into a circularly-symmetric, multi-mode laser beam. The FAP-I is designed to operate under continuous wave (CW) operating

conditions at high, multi-watt output powers for thousands of hours. Waste heat from the laser diode bar is transferred through the FAP-I base to a heat sink.

The FAP-I contains a laser diode bar which efficiently converts electrical energy into optical laser energy. The laser diode bar consists of a multiplicity of independent emitters spaced linearly along a single semiconductor substrate. The output of each of these emitters is captured by a collecting optical fiber. This linear array of fibers in then bundled into a circularly symmetric output.

At low drive currents, the laser diode bar will have insufficient gain to lase. In this operating regime, some light, originating from spontaneous emission, will be visible. As the drive current is increased, the laser diode bar will reach threshold, where it will have sufficient gain to lase. This drive current is the threshold current. Further increases in current will cause a linear increase in output optical power up to the specified operating power.

In general, semiconductor devices perform better at lower operating temperatures. The optical-to-electrical conversion efficiency is higher and the device lifetime is longer. It is desirable to operate the FAP-I at low temperatures (consistent with observing the specified operating temperature limits) to improve performance and lifetime.

The precise semiconductor operating wavelength is also a function of operating temperature. The semiconductor operating temperature is in turn a function of the operating current and case temperature. Control of the temperature is important to bring the wavelengths of the diodes within the absorption window of Vanadate.

Diode/Heat Sink Temperature

The laser diode assembly which houses the FAP-I is mounted on a finned heat sink located in the power supply. The temperature of the diode bars located within the FAP-I is controlled by a TEC. Waste heat from the diode bars is transferred to the passive heat sink.

The heat sink is cooled by fans which exhausts waste heat from the laser diode assembly to the outside of the power supply. Incoming ambient air is filtered by an air filter which can be cleaned periodically depending on the environment.

The laser diodes have an operating temperature range of 5.0°C to 35°C.

PACKING PROCEDURE

The following is the factory recommended packing procedure for the Vitesse laser system. This procedure should be followed if the Vitesse system is to be shipped to another location after initial installation.

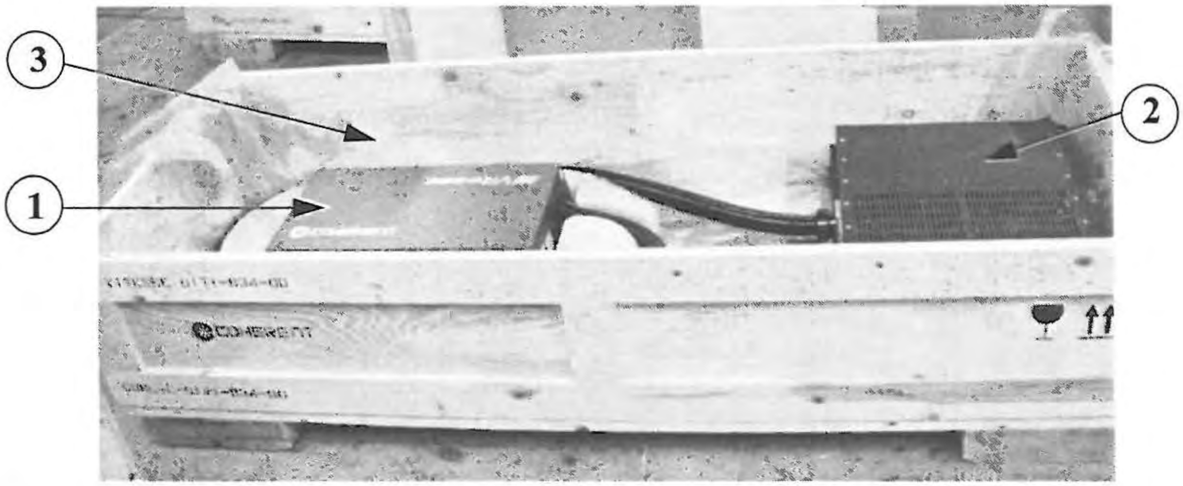
The Vitesse laser system requires one shipping crate. Table A-1 gives a complete listing of the contents of the shipping crate when the system is shipped from Coherent.

The Vitesse system crate consists of a single molded foam compartment. Figure A-1 illustrates the proper placement of each of the components listed in Table A-1. Before placing the laser head and power supply into the crate, to prevent ESD damage, the compartment should be lined with anti-static material. Enough anti-static material should be used so that after the crate is completely packed, the excess can be folded over to cover the top of the power supply, see Figure A-2.

Note that the system documentation and the accessories package should be placed in the cut-out in the top of the foam liner (see Figure A-3).

Table A-1. Vitesse Shipping Crate Contents

1. Laser Head
2. Power Supply
3. Operator's Manual
4. Final Test Data Sheet
5. System Accessories Package
    a. 1/4 inch Water Tubing
    b. Tubing Connectors
    c. Stable Table Clamps (3x)
6. Maintenance Kit
    a. System Fuses (2x)
    b. Diode Shorting Clips (2x)
    c. Fiber Optic Cable End Caps (2x)
    d. Diode Fiber Connector End Caps (2x)
    e. External Interlock Plug, Shorted
    f. External Interlock Plug, Disassembled.



1. Laser Head
2. Power Supply
3. Static Wrap Liner

Figure A-1. Packed Vitesse Shipping Crate

Figure A-2. Packed Vitesse Crate with Anti-Static folded over

Three people are recommended when packing the Vitesse. The laser head and power supply are connected by the umbilical. To prevent damage to the fiber optic delivery cables running between the head and the power supply, the umbilical should be wound loosely in the foam cutout as illustrated in Figure A-1.

Excessively tight fiber bends (less than a 5 inch radius) can cause permanent damage to the fiber optic cables.

Place the Vitesse in the shipping crate as follows:

1. Two people should place the power supply in the cutout as shown in Figure A-1.
2. Two people should carry the laser head clockwise around the shipping container while the third person guides the umbilical onto the cutout as shown in Figure A-1.
3. Place the laser head into the cutout.
4. Fold the excess anti-static material over the top of the system.

Once all components are placed into the shipping crate the top foam should be positioned. After positioning the top foam, the Vitesse Maintenance Kit should be placed in the outer cutout before the crate lid is attached, see Figure A-3.

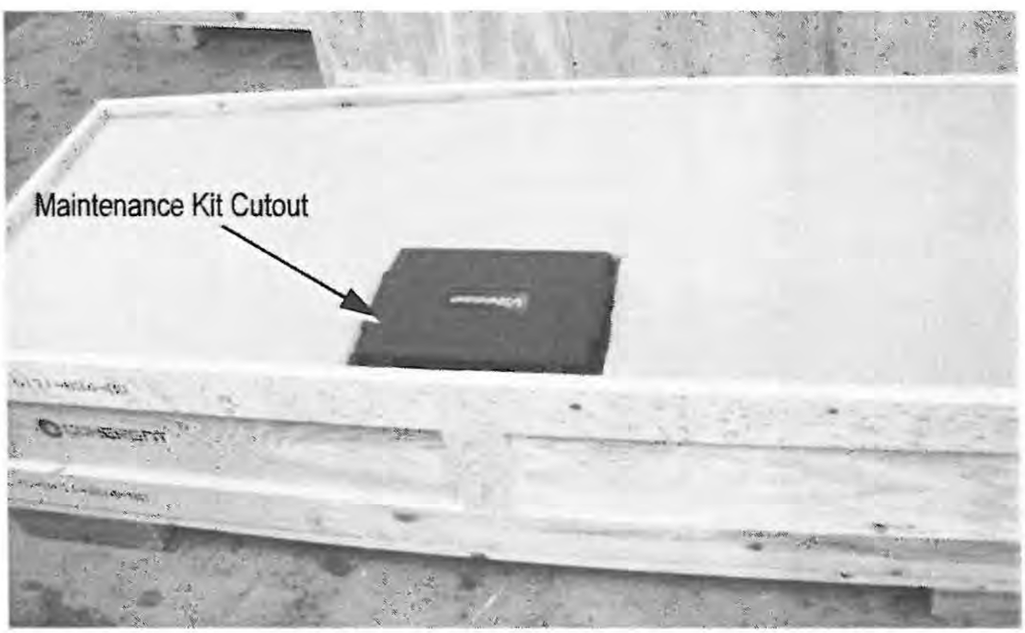


Figure A-3. Location of Packed Vitesse Maintenance Kit

PARTS LIST

DESCRIPTION	PART NUMBER
Fuse	5110-0072
Shipping Crate (System)	0171-834-00
Clamps	0172-826-00

Warranty

Coherent, Inc. warrants the Vitesse laser systems to the original purchaser (the Buyer) only, that the laser system, that is the subject of this sale, (a) conforms to Coherent's published specifications and (b) is free from defects in materials and workmanship.

Laser systems are warranted to conform to Coherent's published specifications and to be free from defects in materials and workmanship for a period of 12 months or 5000 hours of operation, whichever occurs first.

Responsibilities of the Buyer

The buyer is responsible for providing the appropriate utilities and an operating environment as outlined in the product literature. Damage to the laser system caused by failure of buyer's utilities or failure to maintain an appropriate operating environment, is solely the responsibility of the buyer and is specifically excluded from any warranty, warranty extension, or service agreement.

The Buyer is responsible for prompt notification to Coherent of any claims made under warranty. In no event will Coherent be responsible for warranty claims made later than seven (7) days after the expiration of warranty.

Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from:

- Components and accessories manufactured by companies, other than Coherent, which have separate warranties,
- Improper or inadequate maintenance by the buyer,
- Buyer-supplied interfacing,
- Operation outside the environmental specifications of the product,
- Unauthorized modification or misuse,
- Improper site preparation and maintenance, or
- Opening the pump laser head housing.

Coherent assumes no liability for customer-supplied material. The obligations of Coherent are limited to repairing or replacing, without charge, equipment which proves to be defective during the warranty period. Replacement sub-assemblies may contain reconditioned

parts. Repaired or replaced parts are warranted for the duration of the original warranty period only. The warranty on parts purchased after expiration of system warranty is ninety (90) days. Our warranty does not cover damage due to misuse, negligence or accidents, or damage due to installations, repairs or adjustments not specifically authorized by Coherent.

Warranty applies only to the original purchaser at the initial installation point in the country of purchase, unless otherwise specified in the sales contract. Warranty is transferable to another location or to another customer only by special agreement which will include additional inspection or installation at the new site. Coherent disclaims any responsibility to provide product warranty, technical or service support to a customer that acquires products from someone other than Coherent or an authorized representative.

THIS WARRANTY IS EXCLUSIVE IN LIEU OF ALL OTHER WARRANTIES, WHETHER WRITTEN, ORAL OR IMPLIED, AND DOES NOT COVER INCIDENTAL OR CONSEQUENTIAL LOSS. COHERENT SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

GLOSSARY

°C	Degrees centigrade or Celsius
°F	Degrees Fahrenheit
μ	Microns
μrad	Microradian(s)
μsec	Microsecond(s)
$1/e^2$	Beam diameter parameter
AC	Alternating current
Amp	Amperes
CDRH	Center for Devices and Radiological Health
CFR	Code of Federal Regulation
cm	Centimeter(s)
DC	Direct current
EEPROM	Electrically erasable programmable read only memory
EMC	Electromagnetic Compliance
FAP-I™	Fiber array package-integrated
FSR	Free spectral range
I/O	Input/output
kg	Kilogram(s)
LBO	Lithium Triborate, LiB_3O_5
LD	Laser diode
LED	Light emitting diode
LVD	Low Voltage Directive
m	Meter(s)
mAmp	Milliampere(s)
MHz	Megahertz
mm	Millimeter(s)
mrad	Milliradian(s)
msec	Millisecond(s)
mV	Millivolt(s)
mW	Milliwatt(s)
NDM	Negative dispesive mirror
$Nd:YVO_4$	Neodymium:Yttrium Orthovanadate
nm	Nanometer(s)
OEM	Original equipment manufacturer
rms	Root mean square
TEC	Thermo-electric cooler

TEM	Transverse electromagnetic (cross-sectional laser beam mode)
VAC	Volts, alternating current
VDC	Volts, direct current
W	Watt(s)

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Vitesse Laser Operator's Manual

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